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COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
MAR 70 A T NEALE, S STEINBORN, L F KEHNE

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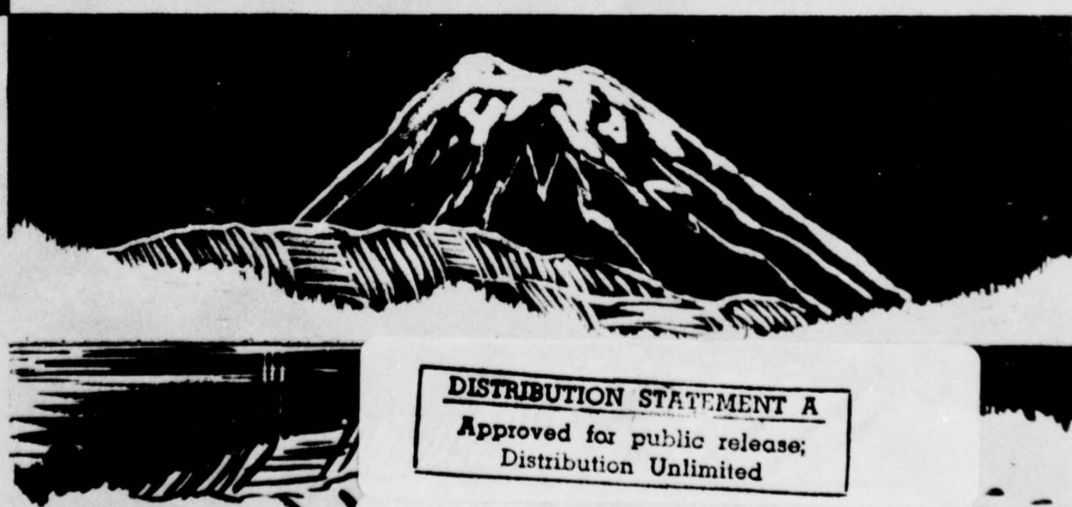
Comprehensive Study of Water
and Related Land Resources

Puget Sound and Adjacent Waters

State of Washington

Appendix V
Water-Related Land Resources

Puget Sound Task Force—Pacific Northwest River Basins Commission



March 1970

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STATE OF WASHINGTON

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Department of Commerce & Economic Development
    Office of Nuclear Development
Department of Fisheries
Department of Game
Department of Health
Department of Highways
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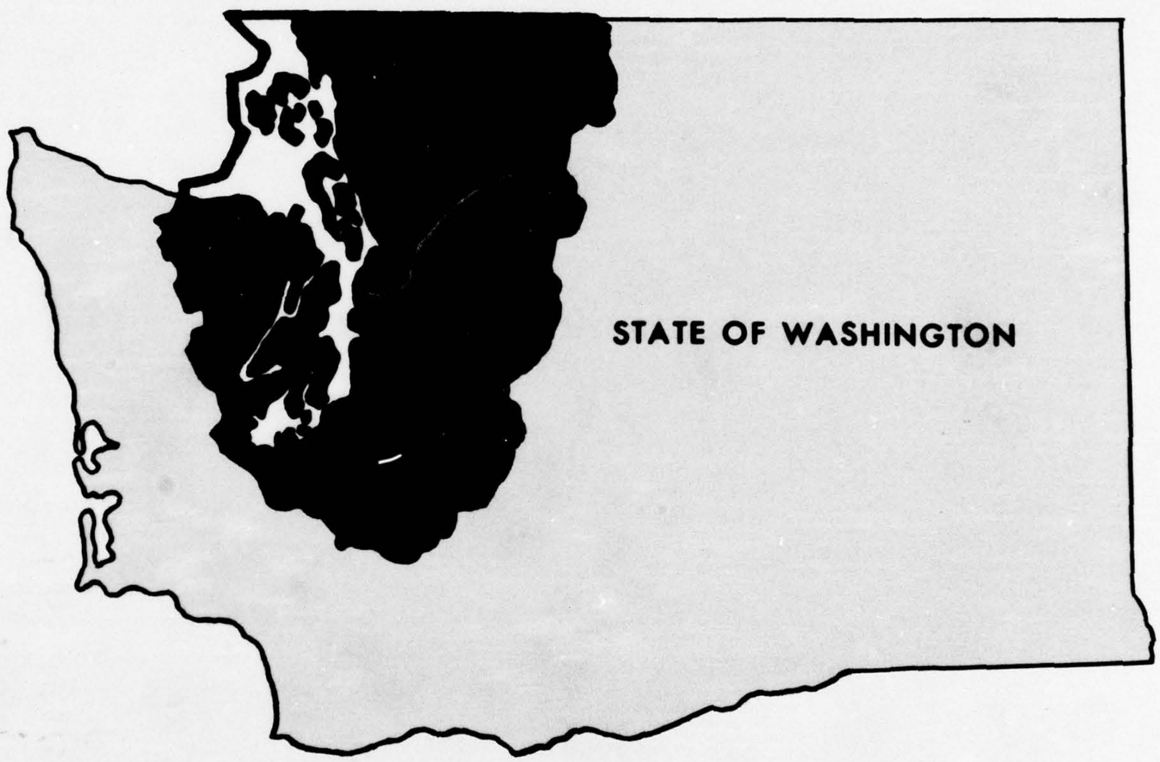
Department of Water Resources
Canal Commission
Oceanographic Commission
Parks and Recreation Commission
Planning and Community Affairs Agency
Soil and Water Conservation Committee
Water Pollution Control Commission



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    Geological Survey
    National Park Service
U.S. Department of Transportation

6

Comprehensive Study of Water and Related Land Resources.

Puget Sound and Adjacent Waters.

APPENDIX V.

WATER-RELATED LAND RESOURCES

10

Alfred T. Neale, Sydney Steinborn,
Lewis F. Kehne L. B. Day,
Francis L. Nelson

11 Mar 70 12 488p.

Land Usage and Development Technical Committee

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PUGET SOUND TASK FORCE of the PACIFIC NORTHWEST RIVER BASINS COMMISSION

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FOREWORD

Appendix V, Water-Related Land Resources, contains a detailed report on the land resources component of the Comprehensive Water Resource Study of Puget Sound and Adjacent Waters. It is one of the technical appendices providing supporting data for the overall water resource study.

The Summary Report is supplemented by 15 appendices. Appendix I contains a Digest of Public Hearings. Appendices II through IV contain environmental studies. Appendices V through XIV each contain an inventory of present status, present and future needs, and the means to satisfy the needs, based upon a single use or control of water. Appendix XV contains comprehensive plans for the Puget Sound Area and its individual basins and describes the development of these multiple-purpose plans including the trade-offs of single-purpose solutions contained in Appendices V through XIV, to achieve multiple planning objectives.

The purpose of the Water-Related Land Resource Appendix is to evaluate the present status of the land and related water resources for agriculture, forests, minerals and intensively used land; to project the probable future levels of land requirements for the years 1980, 2000 and 2020; and to translate such projections in terms of development, availability of land and water resources, and alternative means for solution of problems.

River-basin planning in the Pacific Northwest was started under the guidance of the Columbia Basin Inter-Agency Committee (CBIAC) and completed under the aegis of the Pacific Northwest River Basins Commission. A Task Force for Puget Sound and Adjacent Waters was established in 1964 by the CBIAC for the purpose of making a water resource study of the Puget Sound based upon guidelines set forth in Senate Document 97, 87th Congress, Second Session.

The Puget Sound Task Force consists of ten members, each representing a major State or Federal agency. All State and Federal agencies having some authority over or interest in the use of water resources are included in the organized planning effort.

The published report is contained in the following volumes:

SUMMARY REPORT

APPENDICES

I. Digest of Public Hearings
II. Political and Legislative Environment
III. Hydrology and Natural Environment
IV. Economic Environment
V. Water-Related Land Resources
 a. Agriculture
 b. Forests
 c. Minerals
 d. Intensive Land Use
 e. Future Land Use
VI. Municipal and Industrial Water Supply
VII. Irrigation
VIII. Navigation
IX. Power
X. Recreation
XI. Fish and Wildlife
XII. Flood Control
XIII. Water Quality Control
XIV. Watershed Management
XV. Plan Formulation

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WATER-RELATED LAND RESOURCES

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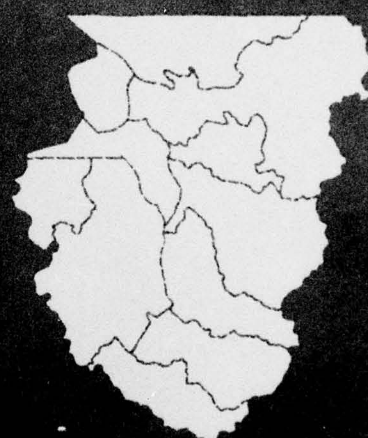
Part One
Introduction



PART ONE—INTRODUCTION
PUGET SOUND AREA
INTRODUCTION

GENERAL DESCRIPTION

The Puget Sound and Adjacent Waters Study is a broadly based, comprehensive study of an entire area, considering as many different factors and interests as possible. A number of Federal and State agencies having a variety of interests and responsibilities joined together in a cooperative study effort in order to bring all available resources and expertise to bear on the planning and development of the Area's water resources.

While the major thrust of the Puget Sound Study is directed toward water as a specific resource within the Area, many other factors which are directly and indirectly related to water use and management must of necessity be considered an integral part of the planning process. One of the major related areas of concern is land use and development, particularly on those lands which have a water-oriented characteristic.

The Water-Related Land Resource Appendix has been prepared and reported in five parts These are: Agriculture, Forestry, Minerals, Intensive Land Use, and Future Land Use. The first four parts have been prepared by work groups of experts from the four areas of concern. The total effort is then brought together in the fifth part describing alternative future land use patterns for the Puget Sound Study Area in the year 2020.

RELATIONSHIP OF LAND AND WATER RESOURCES

Water resource use and management planning requires the consideration of land use and development factors in order to present a balanced natural resource program for the Puget Sound Area. Water quantity and quality considerations will directly effect the way in which land can be used. For example, urban development is dependent on the provision of an adequate supply of municipal and industrial water—in the absence of such supplies certain areas will not be developed for these purposes. Similarly, the full development of agricultural lands requires the necessary provision of water resources. Pollution of waters will limit the use to which adjacent lands can be put. Water which is not controlled or managed properly will cause soil erosion, flood damages and similar occurrences which adversely effect the use of land.

Conversely, the manner in which land is utilized will have a significant effect on the water resources of a region. Land uses can increase pollution levels of certain waters, cause run-off and drainage problems, require the provision of extensive (and expensive) water control facilities, impair navigation sites and other similar factors. Joint consideration of land and water uses is required if serious conflicts and misallocations of available resources are to be avoided.

The material presented in this Appendix is primarily concerned with the water-related land resources of agriculture, forests, mining and intensive used lands. While the material presented in this Appendix touches on a wide range of subjects that affect the land resources such as recreation, irrigation, municipal and industrial water needs, watershed management, economics, and a host of other subjects, the presentation is primarily only in the terms of its affect upon the water-related land resources. For a detailed presentation and analysis of the related subjects, the reader should consult the other Appendices. (Note: See list of Appendices in Foreword of this Appendix.)

PHYSIOGRAPHIC SETTING

Within the 15,800 square-mile area designated as the Puget Sound Study Area, (Figure 1-1), there are striking constrasts in types of terrain, resulting in wide variations in the region's water resources. The lowlands contrast markedly with the mountains of the Olympic and Cascade Ranges, which form the region's western and eastern borders. A low divide forms the southern border, separating Puget Sound drainages from the Chehalis River Basin.

Puget Sound itself is an attractive inland sea providing a marine setting for a large part of the region, and is a most important feature to be considered in the comprehensive study. The salt water area of about 1,000 square miles is character-

ized by numerous channels, bays and inlets. South of Admiralty Inlet, the principal entrance from the Strait of Juan de Fuca, the Sound has two main branches. The western branch, Hood Canal, is a long, narrow arm extending southward about 50 miles near the base of the Olympic Mountains. The eastern branch of the Sound is considerably larger, and contains the deep-water harbors of the region's principal cities. Between the two branches is the Kitsap Peninsula, an area of 582 square miles that lies mostly below an altitude of 500 feet. On the Peninsula, as on the islands of the region, available water resources consist of small streams and ground water.

Alluviated river valleys, their broad floors bordered by bluffs and steep hills, constitute an important physiographic feature of the Puget Sound lowlands. The lowland valleys, with their mountain-valley extensions, contain most of the population, industry, and farming of the Study Area. The main rivers of the Area, descending from mountainous headwaters, course through the valleys to meet the salt water of Puget Sound in tidal estuaries. The valleys are separated by plateaus, whose gently rolling surfaces are altered segments of a plain that was formerly continuous. Terraces, lakes, and marshy depressions diversify the terrain on the plateaus. In much of the Area, the transition from broad, hilly lowlands to mountains is rather abrupt.

In the Cascade Range, which flanks the eastern part of the Area, the principal rivers head at altitudes where precipitation is abundant and where large amounts of snow accumulate each winter. The higher ridges generally reach an altitude of about 8,000 feet in the north and 5,000 feet in the south. Rising prominently above the rather uniform summit levels of the Cascades are the inactive volcanoes of Mount Baker (10,778 feet), Glacier Peak (10,541 feet), and Mount Rainier (14,410 feet). The 27 named glaciers on Mount Rainier constitute the most extensive glacier system of any peak in the conterminous United States. However, farther north in the Cascades, glaciers are more prevalent than at the latitude of Mount Rainier. The Alpine country of the North Cascades, with its many rugged peaks, glaciers, and wild rivers, is truly an area of spectacular scenic beauty.

The Olympic Mountains on the west side of the region are similarly rugged and scenic. They are generally at a lower altitude than the peaks of the North Cascades. Within Olympic National Park is a complex system of deep valleys and canyons, separated by sharp ridges and peaks that commonly attain altitudes of 6,000 feet. In contrast to the Cascade Range, there are no volcanic peaks in the Olympic Mountains. Streams abound; the headwaters of the largest rivers originate at glaciers and snowfields of the major peaks. On the north, relatively narrow, hilly lowlands lie between the Olympic Mountains and the Strait of Juan de Fuca. On the east, where the descent from the mountains to Hood Canal is abrupt, the only significant water-resource development is in the Skokomish River Basin.

Land Cover

The native land cover of the Puget Sound Area is dominated by a dense conifer growth. Grassland prairies and open park-like areas occur where the soil-moisture-temperature (i.e., low effective moisture) relationships create an environment better suited to grasses than trees.

Douglas fir, the most common forest species, is found throughout the Puget Sound Area, particularly on well drained soil. The imperfectly and poorly drained soils have a soil-moisture environment better suited for western hemlock, western red cedar and red alder than to Douglas fir. Consequently, Douglas fir restocking is suppressed, due to moisture-light relationships.

Lodgepole pine is suited to growing on soil-moisture environments ranging from the low-lying, very wet, peat bogs to somewhat excessively drained soils. Sitka spruce is suited to growing on moist soil areas, where precipitation exceeds 50 to 60 inches annually. Restocking following logging or burns, at higher altitudes, where annual precipitation exceeds 60 inches and the mean annual temperature is below 45° to 50°F., is primarily dominated by western hemlock, mountain hemlock, silver fir and noble fir. Bigleaf maple and willow occur throughout the conifer woodlands on well-drained, imperfectly-drained and poorly-drained upland, terrace and bottom land soil areas. Blackcottonwood occurs on bottom land soil areas subject to periodic flooding.

The understory vegetative cover varies with soil-moisture-light relationships. Vine maple, willow, dogwood, cascara, elderberry, evergreen blackberry, trailing blackberry, red huckleberry, snowberry, salmonberry, thimbleberry, Oregon grape, ocean spray, devils club and wild rose in varying combinations dominate the understory cover of this soil-moisture relationship area consists of bracken fern, a

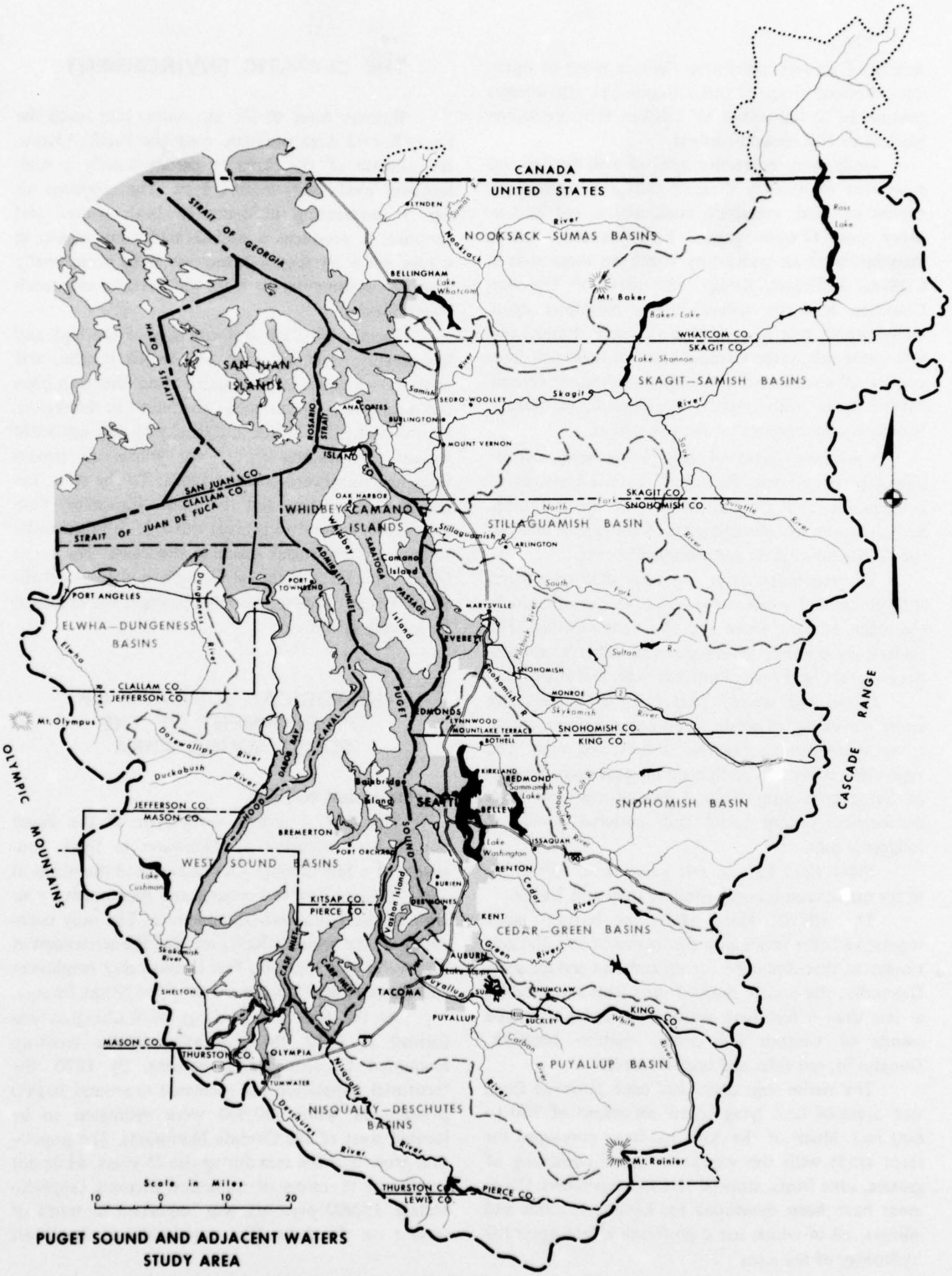


FIGURE 1-1. Basins in the Puget Sound Area

variety of mosses and forbs. Ground cover of open, noncultivated areas, of this soil-moisture relationship commonly is dominated by bracken fern, evergreen blackberry and horsetail sedges.

Understory vegetative cover of well-drained and somewhat excessively drained soil areas commonly consist of salal, evergreen huckleberry, red huckleberry and Oregon grape. Rhododendron grows abundantly as an understory shrub on these soils in Clallam, Jefferson, Kitsap, and parts of Thurston Counties. Madrona occurs on low elevation, open, well-drained, and somewhat excessively drained soil areas near salt water. Ground cover of these soil areas consist of sword fern and mosses in moist, densely shaded areas, with mosses, kinnikinnik, manzanita, snowberry, and grasses on the open areas.

Vegetative cover of the prairie areas consist primarily of grasses. However, scattered stands of Douglas fir and Oregon white oak are common. Scotch broom has invaded parts of the prairie areas to the detriment of grass and woodland cover.

The vegetative cover of poorly drained mineral soils consists of western red cedar, western hemlock, red alder, quaking aspen and black cottonwood. The understory consists of evergreen blackberry, spiraea, ocean spray, wild rose, skunk cabbage, and tules.

Sedge and woody peat bogs have vegetative cover consisting of western red cedar, spiraea, ocean spray, evergreen blackberries, sedges, and tules. The vegetative cover of the Sphagnum peat bogs consists of living sphagnum moss, Labrador tea, low bush cranberries, swamp laurel and scattered stands of lodgepole pine.

Tidal flats have a salt grass cover and fresh water marshes commonly support tules and sedges.

The alluvial flood plains or bottom lands vegetative cover varies with the degree of soil drainage similar to that discussed for upland and terrace soils. Generally, the poorly drained soils with water tables at less than 5 feet have western red cedar or mixed stands of western red cedar, western hemlock, Douglas fir, red alder and bigleaf maple.

The native vegetation has been removed from vast areas of land lying below elevations of 500 to 600 feet. Much of the Area has been developed for farm lands with the vegetative cover consisting of grasses, cane fruits, strawberries and vegetables. Other areas have been developed for highways, cities and villages, all of which has a profound effect upon the hydrology of the Area.

THE CLIMATIC ENVIRONMENT

Because most of the air masses that reach the Puget Sound Area originate over the Pacific Ocean, the climate of the Area is predominately a mid-latitude, west-coast, marine type. The maritime air has a moderating influence in both winter and summer; it produces a well-defined rainy season in winter and a dry season in summer. Only occasionally does dry continental air from the north or east reach Puget Sound.

Terrain, position and intensity of the high and low-pressure systems over the North Pacific, and westerly winds, as well as distance and direction from the ocean, have an influence on climate in the region. To the east, the Cascade and Rocky Mountains shield western Washington from cold winter air masses travelling southward across Canada. To the west, the Olympic Mountains and the Coast Range on Vancouver Island tend to protect this area from the more intense winter storms reaching the coast. The Strait of Juan de Fuca, Strait of Georgia, and the Chehalis River Valley provide low-level passages for maritime air moving inland.

HISTORICAL SUMMARY OF DEVELOPMENT OF THE PUGET SOUND AREA

Development to 1870

The first American settlement of the Puget Sound Area occurred at Tumwater in 1845, consisting of a few families who had crossed the plains in 1844, coming first to Portland and then north a year later to the Tumwater-Olympia area. The only occupancy of the region which preceded the settlement at Tumwater was that of a few Hudson Bay employees and trappers who located a post in the Nisqually area.

At the time the Territory of Washington was formed in 1853, the population of the territory amounted to some 4,000 persons. By 1870, the territorial population had increased to around 30,000 persons, of which 20,000 were estimated to be located west of the Cascade Mountains. The population growth of the area during the 25 years, while not significant in terms of numerical increase (approximately 15,000 persons), was important in terms of impact on the Area. The population of the Puget

Sound Area was only a few persons in 1845, and the bulk of the Area consisted of wilderness, inhabited by a few Indians and fur trappers. By 1870, many small settlements had developed along the Sound. The forests were rapidly being cut in many places, and many lands were being converted to agricultural use. In this relatively short span of time (1845-1870), the Area had been transformed from a wilderness to the beginnings of a major settlement and development area, as described in the following paragraphs.

Commerce–The main exports from the Area at this time were lumber, coal, agricultural products (basically cereals and small fruits), livestock, fur and fish. The principal export was lumber, the principal activity was the production of lumber. Of the some 60 lumber mills in the territory, 16 were located on Puget Sound waters–these were the main producers of lumber for export, the remainder existing mostly for local consumption. In 1870, some 130 million board feet of lumber was produced in the Area, the logs by this time being rafted down rivers to the Sound even though considerable stands of timber remained on the banks of the Sound itself.

Manufacture–With the exceptions of lumber, there were no major manufacturers at this time. A few tanneries, door and sash and furniture factories, and several small iron foundries existed, but these did not have sufficient capacity to even meet local demand.

Shipping–The territory had some 80 sailing vessels with a combined tonnage of 20.5 thousand and 22 steam vessels of 2.0 thousand tons, totaling 102 vessels with a capacity of 22.5 thousand tons.

Land Areas–The Area was at this time largely composed of timber land. However, settlers were moving into the bottom lands along the rivers and clearing them for farms–particularly those areas having rich alluvial deposits. There were large areas at this time where no settlement had occurred. The land office at Olympia had sold or recorded certificates for 635,500 acres of land.

Railroads–At this time rail connections had yet to reach the Puget Sound Area. Surveys had been made and construction of a North-South line was underway and scheduled for completion in 1876.

Urban Settlements–By 1870 there were six (6) towns in the Area with a population of over 200. These were Olympia (1,800), Tumwater (250), Steilacoom (300), Seattle (1,800), Port Townsend (800), and Port Gamble (300). There were around ten other settlements (including Tacoma) with populations between 100–200 persons–mostly supported by a major lumber mill. It is interesting to note that, at this same time, Victoria, British Columbia had a population of 4,000 and Portland contained over 12,000 persons.

Development 1870–1940

The growth and development of the Puget Sound Area advanced rapidly after 1870. The following is a chronological listing of some of the major developmental events occurring in the Area during this period:

1890–Population: State, 357,232; Seattle, 42,837; Tacoma, 36,000.

1891–Great Northern Railroad reaches Everett; Puget Sound Naval Yard (Bremerton) established; City of Everett founded.

1893–Great Northern reaches Seattle; long distance telephone service started between Seattle, Tacoma, Spokane and Portland.

1895–University of Washington moves to present campus location.

1897–Gold rush to Alaska begins, causes rapid development of the Area.

1898–Hydroelectric plant built at Snoqualmie Falls.

1899–Cedar River watershed established to supply water to Seattle.

1900–First automobile arrives in Seattle. Population: State, 518,100; Seattle, 88,670; Tacoma, 37,714.

1906–Lake Washington ship canal gains approval from Congress. First automobile registration in State totals 763 cars.

1909–Milwaukee Railroad completed to Seattle and Tacoma. Alaska-Yukon-Pacific Exposition opens in Seattle.

1910–Population: . State, 1,149,990; Seattle, 237,194; Tacoma, 83,743. Tacoma approves municipal dock facilities and begins construction of the Nisqually hydropower plant; Union Pacific Railroad reaches Seattle.

1911–Port of Seattle established.

1913–State highway development program started.

1914–Smith Tower completed in Seattle.

1915–Snoqualmie Pass Highway completed.

1916–Boeing Company commences manufacturing operations.

1917–Fort (camp) Lewis established. Lake Washington ship canal opened.

1918–Seattle begins hydropower development on the Skagit River.

1920—Coastal air mail service established. Population: State , 1,356,621; Seattle, 315,312; Tacoma, 96,965; Everett, 27,644; Bellingham, 27,585.

1924—Gorge Power Plant on Skagit River operational.

1927—Boeing Airport construction started.

1930—Population: State, 1,563,196; Seattle, 365,583; Tacoma, 106,817; Bellingham, 30,823; Everett, 30,567.

1932—Seattle completes Diablo Dam on Skagit.

1934—Direct transcontinental air service begins to the east.

1938—Congress creates Olympic National Park.

During the period from 1890 to 1940, the development of the Puget Sound Area progressed rapidly. In the decade between 1900—1910 alone, the State's population increased by 600,000 persons. The bulk of this growth occurred in the Puget Sound Area, due largely to the Alaskan gold rush, the rapid expansion of the timber industry and the demand for free land under the homestead laws.

By 1940, the Puget Sound Area had become a manufacturing, wholesale and distribution, commercial, financial and transportation center of major significance, not only on the west coast, but nationally as well. Several of these developmental factors are outlined below as indications of this growth.

Agriculture—The number of farms statewide increased from some 33,000 in 1900 to slightly over 84,000 in 1935. While many of these were located outside the Area, a great deal of dairy, fruit, and vegetable farming developed within the Area due to, (1) the increasing urban population and, (2) the favorable climate for these activities in the Puget Sound Area. There are presently 91,700 acres under irrigation in the Puget Sound Area.

Transportation and Commerce—Prior to 1890, the Area's transportation depended on sailing vessels, coastal steamers and a few crude wagon roads. Travel was slow and difficult, shipment of commodities to and from the region was limited and consequently, this aided in restricting the economic growth of the region. However, soon after 1870, and increasingly up until around 1900, rail connections were made with the Area, both with the East, North, and South. The development of many spur lines in the period from 1888 to 1915 effectively opened the resources of the State to exploitation, making it possible to send Washington products to the eastern states and to tranship American products to the Orient.

The construction of the railroads had a tremendous effect on water transportation in the Area. These effects were: (1) a reduction in water-borne commerce traffic between the Pacific and Atlantic seaboards; (2) an increase in Oriental trade; and (3) an increase in coastal trade. The following figures indicate the increase occurring in the water-borne commerce of this Area:

	Imports	Exports
1890	$ 417,000	$ 2,708,000
1914	55,392,000	55,012,000
1916	161,780,000	200,448,000
1929	216,774,000	147,570,000

In 1905, when the office of Highway Commissioner was created by the Legislature, there were twelve State roads of various length, mostly short, unimproved wagon roads. By 1910, the total mileage in the State had reached 35,560 and by 1920, 44,000 miles, of which over 4,000 miles were improved State highways. The growth of automobile transportation is best indicated by the rapid and substantial increase in the number of cars in the State. While in 1906 there were some 763 cars registered by 1921 there were 195,000, and by 1939, 400,000.

Manufacturing—Once rail transportation opened the Puget Sound Area to outside contact, many other areas of activity experienced considerable growth. Between 1900 and 1910, the State of Washington rose from 30th to 21st place among other states as measured by the value of its manufacturing products. By 1920, factory employees had doubled (over 1910 figures), factories had increased by one third, value of products increased by 200 percent and the State had risen to 14th place in the nation's manufacturing lists.

Development: 1940 to 1966

Between 1940 and 1960 the population of the State of Washington, as a whole, grew by over 1,100,000 persons for an increase of some 64.3 percent (compared to 35.7 percent for the nation during this same time). The twelve-county Puget Sound Area accounted for the largest portion of the State's growth, having a population increase of some 760,000 persons, or nearly 70 percent of the total

population growth of the State. Within the Area itself, the bulk of the population growth occurred in the geographic heart of the Puget Sound Area, composed of King (430,000 additional persons), Pierce (139,000), Snohomish (83,400), and Kitsap (39,800), having a total increase of nearly 693,000 persons amounting to over 90 percent of the total areawide population growth. Not only did the bulk of the State's population increase from 1940 to 1960 occur in the Puget Sound Area, but nearly all of this increase was located in only one portion of the total Area. The effects of such a growth pattern upon the particular land and water resources are extremely significant, far greater than if the growth were more evenly distributed.

The significant population growth of the State in general and the Puget Sound Area in particular during the period from 1940 to 1960 can be largely attributed to the following factors:

(1) Expansion of military bases on the West Coast and the wartime expansion of military contracts for all types of equipment and materials caused the influx of a large number of workers from other parts of the nation, many of whom remained in the Area after the war.
(2) A tremendous backlog of demand for housing and consumer goods in the immediate postwar period spurred the Area's economy, creating many new jobs and services.
(3) The sharp rise in birth rates, both in the nation and in this Area.
(4) Continued decline in mortality rates.

Estimates made in 1966 indicate that the State and the Puget Sound Area have experienced considerable population growth and development from 1960 to the present. These figures indicate an increase of approximately 266,400 persons in the State, with the Puget Sound Area receiving a little over 70 percent of this amount for an increase of 196,000 persons. Once again, the Central portion of the Area obtained the largest amount of this population growth with an estimated increase of 181,000 persons.

The State's 1966 population totaled some 3,120,000 persons, with the Puget Sound Area having a population of 1,965,000 persons, where a hundred years ago there were less than 20,000 persons, today, there resides a population of nearly two million.

Prior to 1940, the development of the Area was one of largely a gradual one, with several periods of more rapid growth, particularly between 1900 and 1910 when the population of both the State and the Area more than doubled. After 1940 the Area's growth and development, building on the foundations set in prior years and impelled by the urgent wartime and immediate postwar economic requirements, shot forward in boom and near-boom conditions. In more recent years, development has tended to stabilize somewhat with intermittent periods of rise and decline. At the present time, the Puget Sound Area is once again experiencing a rapid growth rate, largely due to significant expansion of the Area's aerospace industry.

While development of the Area prior to 1940 was of a significant nature, the greatest impact on the Area's land and water resources has occurred in the postwar period. Not only has the sheer number of people and activities crowding into this area been of significance, but even more significant has been the manner in which they have arranged themselves within the Area. Prior to 1940, urban-type development was, for the most part, reasonably compact, the remainder of the Area being occupied by small villages and farms. However, due to technological advances in communications, transportation, and other factors, more recent development has been scattered widely. Entirely new communities have sprung up, formerly rural areas are now interspersed with urban-type residences and other activities. Now it is possible to easily travel throughout the Puget Sound Area in a matter of hours, and the continued improvements in access will considerably lessen existing travel time constraints. Unless there is a significant reversal of existing trends, developmental impact on all aspects of the Area's land and water resources will continually grow greater, posing more and more pressing problems for the people of the Puget Sound Area to solve.

SUMMARY OF PRESENT STATUS

The Puget Sound Area has developed through the years as a producer of various natural resources, the primary resource being the vast timber reserves. The land areas surrounding the Sound were originally almost completely covered with dense stands of timber. The vast amount of valuable timber resources easily available for logging and milling, due to the proximity of the timber to water areas, led to the early settlement of the Puget Sound Area. With the rapid urbanization that has taken place in the Study Area in past years, the Puget Sound Area is now the foremost population center of the Pacific Northwest. Yet we still find approximately 90 percent of the land is still being put to non-intensive types of uses, with the primary use still being forest lands.

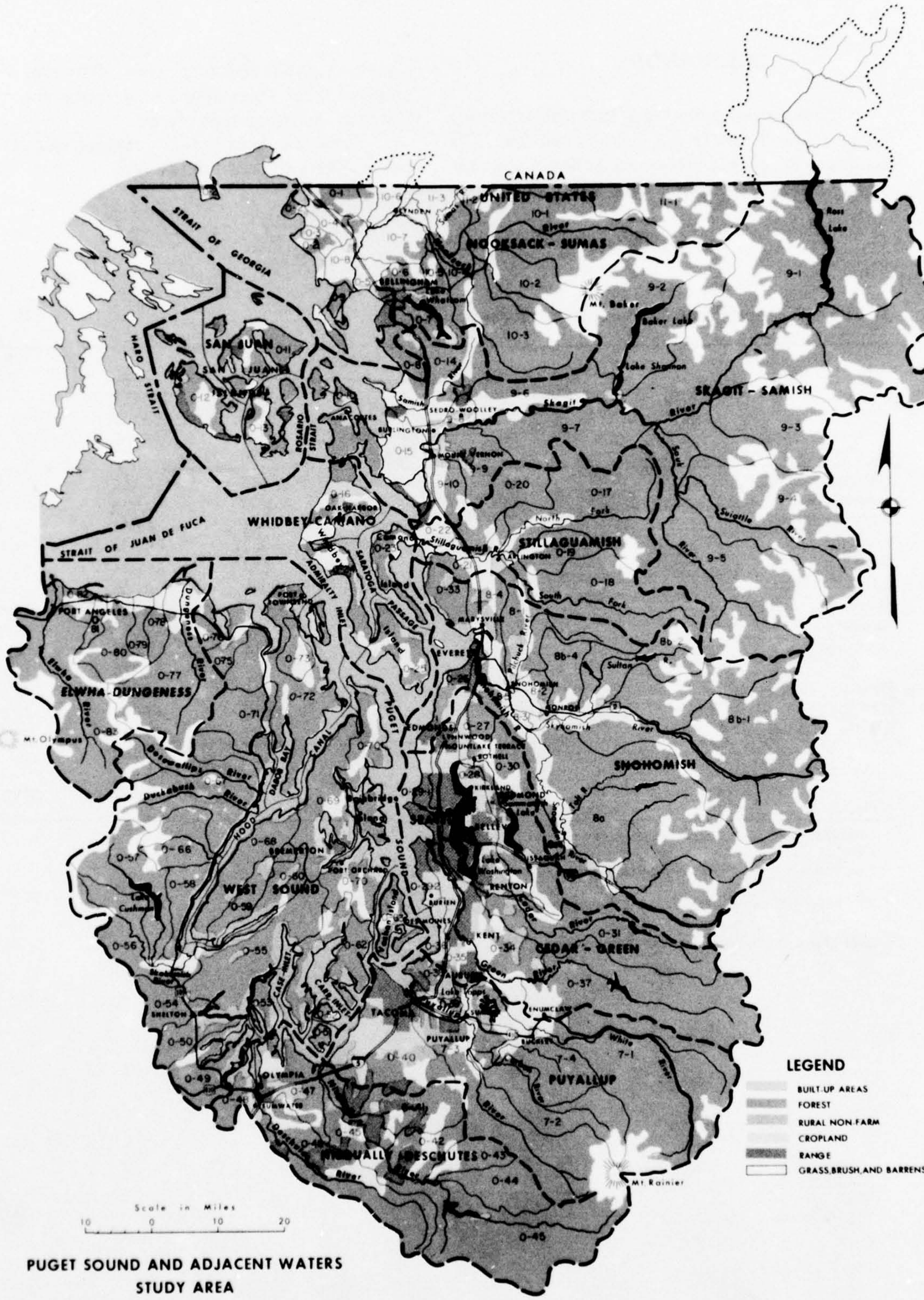
The present land use for the Puget Sound Area has been summarized in the following six tables. Table 1-1 is a composite of all the land uses found in each basin, with a total figure describing the Puget Sound Study Area. Tables 1-2 through 1-6 provide a breakdown of the five major land use classifications. Table 1-7 gives a detailed description of the land ownerships for each of the basins and for the total Study Area.

THE PUGET SOUND AREA

Table 1-1 describes the land use of the Puget Sound Study Area by means of six major land classifications for each of the thirteen (13) basins, and the total for the Study Area. Figure 1-2 portrays the arrangement of the present land use for the Puget Sound Study Area. From Figure 1-2 and Table 1-1, it is easy to see that the primary land use in the Study Area is forest lands, which cover 85 percent of the land.

TABLE 1-1. Land use of the Puget Sound Area 1967 (in acres)

Basin	Cropland	Rangeland	Forest Land	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
Nooksack-Sumas	137,492	11,600	609,581	12,669	20,896	12,129	804,367
Skagit-Samish	100,465	19,748	1,753,445	20,092	18,804	35,409	1,947,963
Stillaguamish	34,531	1,016	385,450	5,932	6,698	4,721	438,348
Snohomish	71,752	2,424	1,054,699	29,360	36,355	23,861	1,218,451
Cedar	20,279	1,120	210,641	25,379	106,516	32,888	396,823
Green	33,103	2,232	236,047	8,966	59,885	5,950	346,183
Puyallup	36,853	5,683	593,339	25,729	97,446	11,297	770,347
Nisqually	29,254	34,008	379,675	6,368	5,481	7,468	462,254
Deschutes	16,248	9,480	127,123	13,541	14,416	2,597	183,405
San Juan	18,594	9,129	71,958	9,118	2,774	955	112,528
Whidbey-Camano	23,006	2,454	84,069	12,419	10,987	719	133,654
West Sound	46,215	5,137	1,123,666	64,208	42,161	12,606	1,293,993
Elwha-Dungeness	23,721	2,417	409,491	5,073	5,911	1,844	448,457
Puget Sound Study Area Total	591,513	106,448	7,039,184	238,854	428,330	152,444	8,556,773



PUGET SOUND AND ADJACENT WATERS
STUDY AREA

Generalized Land Use

FIGURE 1-2

CROPLANDS

There are 591,000 acres of land presently being put to cropland uses in the Puget Sound Area. The Nooksack, Skagit and Snohomish Basins contain the largest acreages in cropland uses, with over 290,000 acres of 591,000 acre total. Over 80 percent of the cropland in the Puget Sound Area is being put to hay and rotation pasture type of uses.

Table 1-2 describes the cropland uses for the basins and for the Puget Sound Area.

TABLE 1-2. Croplands by type—Puget Sound Area (in acres)[1]

Basins	Crop Types				
	Close Grown Field Crops	Brush Fruit Vineyards Etc.	All Other Row Crops	Hay and Rotation Pasture	Total Acres All Crops
Nooksack-Sumas	2,071	2,597	10,709	122,115	137,492
Skagit-Samish	93	2,047	45,640	52,685	100,465
Stillaguamish	--	--	2,983	31,548	34,531
Snohomish	--	560	5,562	65,630	71,752
Cedar[2]	--	65	870	19,344	20,279
Green	--	643	2,855	29,605	33,103
Puyallup	20	2,215	5,804	28,814	36,853
Nisqually	--	255	300	28,699	29,254
Deschutes[3]	65	245	844	15,094	16,248
San Juan	520	--	--	18,074	18,594
Whidbey-Camano	462	433	672	21,439	23,006
West Sound	20	1,103	1,060	44,032	46,215
Elwha-Dungeness	1,465	202	679	21,375	23,721
Puget Sound Area Total	4,716	10,365	77,978	498,454	591,513

1 Unadjusted measurements correct to the nearest thousand.

2 The Cedar and the Green River Basins have been reported as one unit in the Appendix.

3 The Nisqually and the Deschutes Basins have been reported as one unit in the Appendix.

Source: Puget Sound and Adjacent Waters Study, 1966.

RANGELANDS

Rangelands described in Table 1-3, make up a very small part of the total land acreage in the Puget Sound Area. They represent less than 2 percent of the total. The Nisqually-Deschutes River Basins contain 42 percent of all the rangelands in the total Area.

TABLE 1-3. Rangelands by type—Puget Sound Area (in acres)[1]

Basins	Native Pasture	Brush Pasture	Total Rangeland
Nooksack-Sumas	9,956	1,644	11,600
Skagit-Samish	4,088	15,660	19,748
Stillaguamish	744	272	1,016
Snohomish	1,134	1,290	2,424
Cedar[2]	--	1,120	1,120
Green	--	2,232	2,232
Puyallup	--	5,683	5,683
Nisqually	--	34,008	34,008
Deschutes[3]	--	9,480	9,480
San Juan	7,417	1,712	9,129
Whidbey-Camano	1,689	765	2,454
West Sound	638	4,499	5,137
Elwha-Dungeness	1,164	1,253	2,417
Puget Sound Area Total	26,830	79,618	106,448

[1] Unadjusted measurements correct to the nearest thousand.

[2] The Cedar and the Green River Basins have been reported as one unit within the Appendix.

[3] The Nisqually and the Deschutes River Basins have been reported as one unit within the Appendix.

Source: Puget Sound and Adjacent Waters Study, 1966.

FOREST LANDS

Forests

Forests occupy some 6.4 million acres, or about 75% of the total land acreage. The Skagit, Snohomish and West Sound Basins contain the largest acreage of forest, holding about 55% of the Area's total. Forest land classification indicates that 13% of the acreage is noncommercial forest. Another 9% is productive land held in reserved status in parks, wilderness, or like units. The remaining 78% is classified as commercial forest land capable of—and available for—the production of forest products. Coniferous species predominate, making up some 81% of the total stand. The most common species is Douglas fir, with western hemlock, western red-cedar and the true firs making up most of the remaining stand. Table 1-4 describes the present acreage of forest lands in the Puget Sound Area.

TABLE 1-4. Forest land area by basin (in acres)

Basin	Commercial		Non-Commercial	Productive Reserved	Total
	Coniferous	Deciduous			
Nooksack-Sumas	334,880	133,050	37,810	27,190	532,930
Skagit-Samish	677,230	157,500	368,940	201,660	1,405,330
Stillaguamish	271,210	83,020	19,010	3,640	376,880
Whidbey-Camano	69,680	14,880	0	4,820	89,380
Snohomish	581,760	202,300	150,030	53,090	987,180
Cedar-Green	294,100	88,390	7,410	7,860	397,760
Puyallup	369,980	72,180	53,920	66,920	563,000
Nisqually-Deschutes	435,220	51,020	16,850	16,380	519,470
West Sound	870,180	123,830	87,390	55,900	1,137,300
Elwha-Dungeness	87,090	17,380	124,950	112,740	342,160
San Juan	61,120	8,310	0	8,130	77,560
Puget Sound Area Total	4,052,450	951,860	866,310	558,330	6,428,950

Note: Land status changes caused by Public Law 90-544, North Cascades National Park Act, are included in the totals.

Source: USDA, Forest Service—1968.

RURAL NON-AGRICULTURAL

The Rural Non-Agricultural land use of the Puget Sound represents less than 3 percent of the total land within the region. Of the four classifications used in this land use category, the rural non-farm and the mines are the most significant. The areas classified as rural non-farm are important indicators of lands that are in transition from agricultural or forest uses, to intensive land use. Also, it should be noted that rural non-farm areas represent 70 percent of the land classified in the Rural Non-Agriculture land use category. The mines classification is not so important because of its land acreages, but because of its necessity to the Puget Sound for various mineral needs which are vital and necessary to the growth of the Area. An example of mining needs would be the maintenance of its gravel resources in close proximity to the population centers where it is available for use in the construction industry. Table 1-5 describes the Rural Non-Agricultural land use of the Puget Sound Area.

TABLE 1-5. Rural non-agricultural land use—Puget Sound Area (in acres)[1]

Basins	Rural Non-Agricultural Classifications: Rural Non-Farm	River Wash Tidelands	Mines	Farmsteads	Total Rural Non-Agricultural Land Use
Nooksack-Sumas	3,720	4,324	658	3,967	12,669
Skagit-Samish	8,201	--	6,534	5,357	20,092
Stillaguamish	1,602	--	738	3,592	5,932
Snohomish	16,550	403	6,261	6,146	29,360
Cedar[2]	22,864	294	205	2,016	25,379
Green	7,088	135	332	1,411	8,966
Puyallup	21,042	900	137	3,650	25,729
Nisqually[3]	2,557	721	284	2,806	6,368
Deschutes	11,444	293	235	1,569	13,541
San Juan	6,558	730	1,830	--	9,118
Whidbey-Camano	9,687	1,161	133	1,438	12,419
West Sound	56,147	2,492	338	5,231	64,208
Elwha-Dungeness	2,489	988	61	1,535	5,073
Puget Sound Area Total	169,949	12,441	17,746	38,718	238,854

[1] Unadjusted measurements correct to the nearest thousand.

[2] The Cedar and the Green River Basins have been reported as one unit within the Appendix.

[3] The Nisqually and the Deschutes Basins have been reported as one unit within the Appendix.

Source: Puget Sound and Adjacent Waters Study, 1966.

TABLE 1-6. Intensive (built-up) land use—Puget Sound Area (in acres)[1]

Basins	Railroads	Highways	Airports	Urban Residential Industrial	Total Built-Up Areas Land Use
Nooksack-Sumas	613	5,177	294	14,812	20,896
Skagit-Samish	775	8,274	597	9,158	18,804
Stillaguamish	471	3,978	506	1,743	6,698
Snohomish	2,288	8,615	1,841	23,611	36,355
Cedar[2]	1,776	6,008	947	97,785	106,516
Green[2]	1,275	3,289	1,556	53,765	59,885
Puyallup	2,636	4,920	3,270	86,620	97,446
Nisqually[3]	889	3,074	134	1,384	5,481
Deschutes[3]	734	2,025	383	11,274	14,416
San Juan	10	838	639	1,287	2,774
Whidbey-Camano	---	3,088	4,600	3,299	10,987
West Sound	998	10,343	2,123	28,697	42,161
Elwha-Dungeness	230	1,335	413	3,933	5,911
Puget Sound Area Total	12,695	60,964	17,303	337,368	428,330

[1]Unadjusted measurements correct to the nearest thousand.
[2]The Cedar and the Green River Basins have been reported as one unit within the Appendix.
[3]The Nisqually and the Deschutes Basins have been reported as one unit within the Appendix.
Source: Puget Sound and Adjacent Waters Study, 1966.

INTENSIVE LAND USE

The 428,000 acres of land classified in the category of Intensive Land Use constitutes a small part of the total land of the Puget Sound Area, (5%), but it has a tremendous impact upon the total land and water resources of the Area. It is within the built-up areas of the Puget Sound where a great majority of the 1,870,000 persons live, where the great water-users are located, and it is in, and around, these areas where new population growth is going to occur. Of the four classifications listed under the category of Intensive (built-up) Land Uses, urban uses are the most important. This classification includes all the primary urban uses, such as residential, commercial, industrial, public, and semi-public. The urban uses constitute 80 percent of the total land use in this category. Table 1-6 describes the Intensive Land Uses for each of the basins, and for the total Puget Sound Area.

LAND OWNERSHIP

Ownership of land is extremely important to the planning process and, even more important, is the pattern of land ownership. Ownership of land had a definite influence upon the patterns of land use and development in the region in the past, and will continue to have an influence on land use patterns in the future. The Federal Government is the largest land holder in the Area, controlling 41 percent of the land. The next largest identifiable group is comprised of the corporate owners, who can be identified primarily as the large timberland owners. The category listed as "urban, suburban and all other private land" in Table 1-7 is a category that contains over 2,800,000 acres of land and includes all those lands such as homeowners, individual lots, commercial holdings, etc., that are primarily found in or adjacent to the populated portions of the Puget Sound Area.

In examining the ownership patterns from the viewpoint of lands in the public sector (4,401,000 acres) and lands in the private sector (4,147,000 acres) there is almost an equal division within the Puget Sound Area.

Table 1-7 describes the land ownership groups for each of the River Basins, and for the Puget Sound Area as a whole.

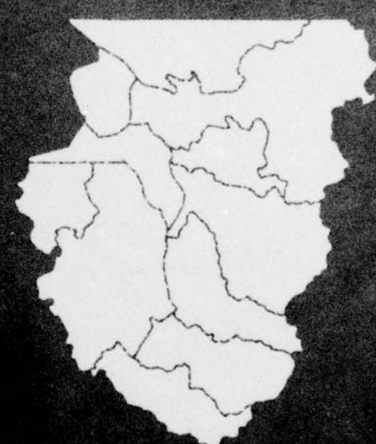
TABLE 1-7. Land ownerships in the Puget Sound Area—(in acres)[1]

Owner	Nooksack	Skagit	Stillaguamish	Snohomish	Cedar	Green	Puyallup	Nisqually	Deschutes	West Sound	Elwha-Dungeness	Whidbey-Camano	San Juan	Total
FEDERAL LAND														
National Forest	202,100	902,070	172,300	419,810	20,830	50,450	135,680	38,040	5,790	229,860	67,330			2,244,260
National Park	67,330	471,670					133,720	35,560		111,170	263,850			1,083,300
Army (includes C.O.E.)		30		90	1,740	1,410	32,140	47,230	6,830	110	630			90,210
Navy	230		5,240		720					13,360		8,110		27,660
Air Force	80			450	70	130	4,510					20		5,260
Indian	7,320	3,450		9,000		200	1,060	830		8,490				30,350
Bureau of Land Management	220	420		420						320			220	1,600
Coast Guard	10	50			10		10			70	330	80	590	1,150
Bonneville Power Admin.	30	10		230	10	40	80		230	60	110			800
Fish and Wildlife					10					30	50		390	480
All Other	60				170	290	40			4,410				4,970
TOTAL FEDERAL LAND	277,380	1,377,700	177,540	430,000	23,560	52,520	307,240	121,660	12,850	367,880	332,300	8,210	1,200	3,490,040
STATE LAND														
Dept. of Natural Resources (does not include tidelands and shorelands)	81,130	88,730	70,890	132,350	7,480	8,610	13,500	47,840	11,150	114,070	26,070	3,980	3,110	608,910
Dept. of Game	1,000	12,740		200		160	280		620	320		790		16,110
Highway Dept.	2,600	2,360	1,000	6,600	3,500	3,200	2,300	800	1,100	3,530	590	710		28,290
State Parks and Recreation Commission	2,010	1,790	500	1,520	300	90	830		110	2,650	40	320	5,820	15,980
Dept. of Institutions		1,110		950			1,870			610				4,540
Dept. of Fisheries	20	100		80	40		20			60	130			450
University														
Univ. of Washington				160	690			2,300		300			480	3,930
Wash. State Univ.		50					330							380
All Other				80	10									90
TOTAL STATE LAND	86,760	106,880	72,390	141,940	12,020	12,060	19,130	50,940	12,980	121,540	26,830	5,800	9,410	678,680
COUNTY LAND														
County Trust Land contained in Department of Natural Resources total above	(36,820)	(58,630)	(53,790)	(56,550)	(7,130)	(2,250)	(6,890)	(6,900)	(6,950)	(56,270)	(50,470)			(342,650)
All other County Land not shown above as County Trust Land This item includes Roads, Parks, Forest, Dumps, Gravel Pits, etc.	1,980	1,560	750	1,590	780	780	990	630	820	2,050	630	600	860	14,020
MUNICIPAL LAND	4,750	6,820	1,400	54,840	91,240	23,520	12,310	1,540	1,950	17,660	1,620	170		217,820
TOTAL ALL PUBLIC LAND	370,870	1,492,950	252,080	628,370	127,600	88,880	339,670	174,770	28,600	509,130	361,380	14,780	11,470	4,400,560
PRIVATE LANDS														
Large Corporate Ownerships from Metsker (confirmed by Company Foresters)	110,120	102,340	47,100	261,230	96,000	38,520	242,400	142,760	37,920	166,880	760	2,000	80	1,248,110
Small Corporate Ownerships	6,080	9,720	1,600	1,840		2,960	720			12,160				35,080
Urban, Suburban and All Other Private	320,920	331,060	140,840	324,680	176,210	206,220	196,110	162,910	103,400	603,270	79,380	117,470	101,000	2,863,470
TOTAL PRIVATE LAND	437,120	443,120	189,540	587,750	272,210	247,700	439,230	305,670	141,320	782,310	80,140	119,470	101,080	4,146,660
TOTAL HYDROLOGICAL AREA	807,990	1,936,080	441,620	1,216,120	399,810	336,580	778,900	480,440	169,920	1,291,440	441,520	134,250	112,550	8,547,220

[1] Acreage figures differ from those presented in the Land Use Tables because of differences in definition of Forest Land and the data collection methods of the U.S. Forest Service and the U.S. Soil Conservation Service.

Source: U.S. Forest Service and the Washington State Department of Natural Resources, 1968.

Part Two
Agriculture - Puget Sound Area



PART TWO—AGRICULTURE
PUGET SOUND AREA

SUMMARY OF AGRICULTURE

PRESENT STATUS

Land use, within the Puget Sound Area, as measured from aerial photography, consists of: cropland, 591,500 acres; rangeland, 106,450 acres; forest and land associated with forest, 7,039,200 acres; rural non-agricultural 238,850 acres; urban built-up, 428,350 acres; and fresth water, 152,450 acres. Of these various categories of land use, this section deals primarily with cropland and rangeland. The other components have been examined only to the extent necessary to establish their effects upon potential cropland.

Cropland has been broken down into major crop groups for detailed examination. These groupings along with their acreages are: Small grains, 13,010 acres; field crops 4,450 acres; vegetables, 54,020 acres; berries, 9,930 acres; nursery products, 7,130 acres; hay, 156,550 acres; silage, 51,910 acres; pasture, 263,040 acres; and cropland not used, 31,480 acres.

Soils outside of national park and national forest boundaries have been grouped into capability classes, subclasses, and units to determine potential cropland, and to estimate types of agriculture best suited to various kinds of land. Capability classes indicate limitations of use. Lands within capability classes II through IV have problems of low intensity and are suited for cultivation. Classes V and VI with greater limitations are suited for pasture and rangeland. Classes VII and VIII have severe limitations for agriculture but may be suited for recreation, wildlife, or water supply. Capability classes II through IV total 2,087,200 acres; Classes V and VI, 1,026,800 acres and classes VII and VIII, 1,577,300 acres.

Subclasses are designated by letters (e) for erosion, (w) for wetness, and (s) for soil problem. These subclasses indicate the kinds of limitations within the classes. The dominant limitation is indicated by the first letter in the small two letter symbolization following the capability class. The capability class indicates severity. All acres in the Puget Sound Area have one or more of these limitaitons; Table 2-2 gives a summary of these conditions.

Soils of the area have been grouped into capability units according to similarity of problems and treatment needs. This serves to condense and simplify the determination of treatment needs and estimation of productivity under various levels of management. Table 2-3 gives acreages of the various capability units by basin. Estimates of present and potential production levels for various crops are shown in Table 2-4.

Much of the cropland, though fertile, has problems which must be solved to meet the needs of the Area. These needs are determined and quantified under "Present and Future Needs."

PRESENT AND FUTURE NEEDS

All needs of the Puget Sound Area are based on the number of people expected by 2020. The Economic Technical Committee has projected 6.8 million people by 2020, an increase of approximately 3.5 times the present population. It is assumed an average urban density of six persons per acre would be suitable for gross land use planning purposes, except for the Cedar Basin. At this density 1,040,000 acres would be needed for urban use or approximately 372,900 acres more than is used at the present time. About 66,500 acres of this 372,900 additional acres needed is expected to come from cropland. The remaining 306,400 acres is expected to come from other land uses.

A loss of 66,500 acres would lower total cropland of the Area to 525,000 acres. This loss of acres coupled with a rapidly expanding population requires increase in production over the present of: 120 percent for forage and small grains; 264 percent for field crops; 255 percent for vegetables; 158 percent for berries; and 264 percent for nursery products.

In order to achieve the needed increases in production the 525,000 acres remaining in cropland must reach a higher degree of development than is presently attained. This can be done by: advances in

technology, floodwater protection, watershed protection and rehabilitation, drainage improvement, irrigation development, and other management.

Floodwater damage hazard must be prevented to the extent remaining hazard does not materially exceed other risk of loss before investments in development are practical. This level of protection is needed on 454,400 acres of cropland by 2020.

Soil erosion and various other aspects of land instability determine watershed protection and rehabilitation measures needed on 525,000 acres of cropland by 2020.

Drainage improvement is needed to improve efficiency of cropland use. Cropland drainage is needed on 482,000 acres by 2020. A considerable amount of this improvement is intensification of treatment on land previously partly drained, and all of the drainage improvement is on lands now in cropland use.

Irrigation in this Area is used to maintain the supply of moisture available for crops at near the optimum level. Irrigation development is needed on 396,000 acres requiring approximately 816,450 acre-feet of water by 2020. This irrigation is of a supplemental nature and serves to increase production efficiency.

MEANS TO SATISFY NEEDS

The plan advanced here is considered to be the most practical in terms of doing the most good for the most people at the least cost.

The need for land for urban development will be met by using most of the land presently classed as rural non-farm, 66,500 acres of present cropland, and approximately 306,000 acres of forested area. This is based on a gross average density of six persons to the acre, for lands to be devoted to urban uses. The best cropland located mainly in flood plains of rivers and tributaries and on low benches would be retained in cropland and other open uses by public incentives and regulation.

Increases in production requirements of the various crop groups will be brought about in a number of ways,

(1) All remaining cropland will be developed for production efficiency, as needed.

(2) Cropland may be shifted between the production of forage and small grains, vegetables, berries, and nursery products as conditions warrant.

(3) Advances in technology will be facilitated by increasing research through more trained personnel and funds.

(4) Install and maintain protection on 454,400 acres of cropland to reduce damages and allow full development of farmlands to meet the share of food and fiber required of the Area. This will be done through a combination of flood control and prevention projects. These projects will be installed through cooperation between local people, the State, and various Federal agencies.

(5) Install or maintain watershed protection and rehabilitation practices on 631,000 acres of cropland and rangeland. These practices are largely the responsibility of the local people with technical and financial assistance of the State and Federal governments.

(6) Install or maintain drainage of unwanted water from 482,000 acres of agricultural land to create a more suitable environment for growing crops to meet increased production requirements. Partial drainage has been installed on much of the land at the present time. However, to meet projected yields, complete drainage must be installed on the 482,000 acres. Many of the early projects have drainage as a purpose.

(7) Install or maintain irrigation on 396,000 acres of cropland. Most of this irrigation will be accomplished through individual effort, although the possibility of at least two federally sponsored projects does exist. Unless the conversion of cropland to other uses is halted, this amount of irrigation will not be accomplished. See Appendix VII, Irrigation.

This plan provides for enough farmland, when fully developed to satisfy needs based on maintaining the expected share of national production in relation to increased national population by 2020 and provides for spacial needs for industrial and urban development during the same time period.

Details of proposed projects and measures including implementation are found in Appendix XIV, Watershed Management.

Other appendices containing information of special interest to agriculture are as follows:

(1) Appendix II, Political and Legislative Environment.

(2) Appendix IV, Economic Environment.

(3) Appendix VII, Irrigation.

(4) Appendix XII, Flood Control.

INTRODUCTION

The United Stated Department of Agriculture considers the word "agriculture" to include: resources, activities, and commodities related to cultivated pastures, woods, forests, and ranges. It then includes all lands used for the production of food and fiber, including such primary and secondary uses as recreation and wildlife. In this appendix the use of the term is primarily restricted to cropland use and factors affecting land use in relation to cropland.

"Related land" is that land on which present or projected use or management practices cause significant effects on the quantity and/or quality of the water resource, and that land, the use or management of which is significantly affected by or depends on existing and proposed measures for management, development, or use of water resources.

Of particular importance to agriculture is the competition for good cropland in the Area. Lands suitable for farming use are in a scarce category. Only about seven percent of the Area is used for cropland and this available land will be decreased by conversion to other uses. In contrast to the supply of cropland there is a plentiful supply of land suitable for other purposes if adjudicated with reasonable judgment and used with adequate intensity in order to decrease areal demands on the resource.

Croplands must satisfy a part of the spatial requirements of the expanding population. This land is for the most part the flood plains of the major rivers and their tributaries. About twelve percent of the Puget Sound Area is expected to be used for urban purposes by 2020. The large amount of available land, other than flood plains, suitable for urban development should make it possible to minimize competition between cropland and urban uses.

Good judgment dictates that land be developed carefully from its natural condition so that irreversible changes are not induced in critical areas needlessly, or without full consideration of the consequences.

PURPOSE AND SCOPE

The purpose of the study is to develop a plan to provide, if possible, the Area's share of expected food and fiber production needs for the Nation to the year 2020.

This appendix is dedicated to methods, means and alternatives to be used in achieving the greatest socio-economic benefits from the limited cropland resources.

In its industry function, agriculture contributes heavily to the economy of the Puget Sound Area through production of food and fiber from land and water in this region of mild climate, long growning season, favorable water supply, and good markets.

The nature and distribution of soils is considered in detail and the interpretations of soil properties are translated in terms of agricultural capability, production potential, and needs for protection and development. (Appendix XIV, Watershed Management, and accompanying exhibit 1 contain information on the suitability of soils for various uses.)

A number of existing programs of technical assistance, informational services, financial and credit assistance influence the land owner in his use and care of the land. These programs are considered in more detail in Appendix XIV, Watershed Management. The functions of various agencies of State and Federal government are described in Appendix II, Political and Legislative Environment.

In order to meet the needs of future years much higher levels of management are required. In order to determine these levels three factors are involved:

(a) The cropland base available.

(b) Estimation of production levels attainable.

(c) Kinds and amounts of management required.

The study develops an inventory of present status of agriculture, determines need for cropland to 2020, and develops a program, which on implementationwill meet the spatial needs of an expected population of 6.8 million and produce the Area's expected share of national production to 2020.

HISTORICAL BACKGROUND OF AGRICULTURE

Though production records prove that the agricultural opportunities contained in the varied climate and soil of Washington State are among the best of any state, and though agriculture may be said to have been practiced almost scientifically since the arrival of the first settlers, the development of the

State's agricultural resources was delayed for decades and has not yet reached its full diversity or capacity. The following historical material has been compiled from published and unpublished historical records of the area by the Washington State Department of Agriculture.

The Spaniards had brought cattle to Nootka Sound in 1789 and in 1792, during their brief occupation of Neah Bay, had landed eight head of cattle, and poultry, hogs, goats, and sheep. At Astoria, in 1814—then Fort George—there were chickens and goats, two bulls and two heifers being brought the same year from San Francisco by the ship Isaac Todd. Continued importations raised the number of cattle to twelve. Little agriculture was practiced there, the personnel being exclusively fur traders; livestock was allowed to run as on open range, and potatoes were apparently the only field crop cultivated to any extent. Farming was followed as an economic enterprise only after the arrival of Dr. John McLaughlin, a manager of the Hudson's Bay Company on the Pacific Coast, on the Columbia River in 1824.

Dr. McLaughlin was the pioneer in the development of the Pacific Northwest; he saw its potentialities, foresaw its growth and initiated many of the basic industries upon which its prosperity would rest. While the company he represented was a fur-trading company, Dr. McLaughlin realized that the future of the Oregon Territory was largely agricultural and turned much of the activity of the Hudson's Bay Company into farming and stock raising. Upon the establishment of Fort Vancouver, in 1825, he banned the slaughter of cattle and began the cultivation of the land. No cattle, or very few, were killed for beef until 1836, when the twenty-seven head he found when he arrived had multiplied into a herd of approximately 1,000 head. In addition to the 1,000 head of cattle there were some 700 hogs, 200 sheep, 500 horses, and 160 oxen. Not all of this stock was at Vancouver, for Dr. McLaughlin sent cattle and hogs to the company posts at Colville, Nisqually, Cowlitz, and to more distant forts; and he lent cows to settlers to encourage emigration and the development of the territory. His management of crop growing was similar. Seed was sent to the several company posts and given to settlers.

Seed of grain, fruits and vegetables was also a part of the baggage of these earliest settlers. Farming was being practiced in the most advanced methods of the day. As early as 1895 farmers around Sequim formed an irrigation company to water lands from the Dungeness River.

In 1838 stock holders of the fur company, whose charter did not provide for agricultural activity, organized the Puget Sound Agricultural Company. The two largest farms, or ranches of the Agricultural Company were located at Nisqually and Cowlitz.

The Simmons group, who settled at Budd's Inlet near the present town of Tumwater at the head of Puget Sound, were the first American settlers to enter the State of Washington who were neither traders nor missionaries, but were seeking permanent homes.

Farming was slow in becoming the State's second economic enterprise, lagging behind logging in the western and behind mining in the eastern parts of the State.

Between 1848 and 1850 other settlers went into the land of the Columbia River, packing some grafts and fruit trees with them. Other plants, seeds, and fruit trees were brought to the Sound in ships. Small nurseries were started and a number of orchards set about Olympia—then Tumwater—Steilacoom and in the Puyallyp and White River valleys. Whatcom, Island, Mason, and Clark Counties were the principal agricultural centers of western Washington.

In the sixties the King County market gardening was already becoming a major industry on land that was being logged off since the late forties and early fifties. Dairying was developed into a specialized occupation, and the potentialities of orchard culture were beginning to be recognized.

The establishment of formal banking in the State in 1869 was the beginning of Washington's financial history. Banking in the Pacific Northwest was an outgrowth of other business enterprises. Real estate agents came to the front as leading business men and in that period shared with merchants in starting banks.

During the seventies favorable Federal legislation in regard to land grants stimulated and encouraged settlements even in advance of the public survey.

In the counties bordering the Sound, vegetable gardening and berry culture were well advanced with cabbage, aspargus, beans (except Lima), beets, brussels sprouts, cauliflower, carrots, celery, cucumbers, kale, leeks, lettuce, onions, parsely, parsnips, peas, potatoes, radishes, rhubarb, spinach, squash, turnips, blackberries, currants, gooseberries, raspberries, strawberries, and a certain variety of peaches in

favorable locations being staple crops.

As more and more settlers entered the Territory, the fitness of its different sections for certain crops or specialized agriculture was better recognized. By 1880 most agriculture was being localized and developed along the lines it has since followed in each section of the State.

Lumber companies who had purchased timberlands from early homesteaders, the railroad land grants and the state school lands were important factors in the farm settlement pattern. As the timber was harvested, thousands of acres of logged-off land were made available for settlement at low prices. Purchase and settlement of these lands was very common in the islands and fringes of Puget Sound.

In 1890 the Puget Sound Area was becoming a center of berry culture, the land yielding from 2,000 to 3,000 pounds of strawberries per acre. Shipments of early berries were successfully made to cities as distant as Chicago and St. Paul. Apples, plums, prunes, and cherries were for some years extensively cultivated in the island counties; with cherries thriving in the humid atmosphere of the Sound country. Scattered nurseries occupied several hundred acres, and were doing a good business in, largely, winter apple and prune trees. Market gardening also was a growing industry in western Washington and on the land adjacent to the Sound, where the soil and climate were uniquely adapted to the production of vegetables. Celery and asparagus were being grown for export markets. During this period hop cultivation in the Puyallup Valley was flourishing, yields there being exceeding heavy, and the aphis which was later to cause destruction of the hop fields not yet having appeared. Close to 650,00 bushels of oats were grown in Skagit County.

Livestock industries experienced a great impetus during the twenty years preceding 1900. Among these, dairying was the foremost, climate, forage crops,and markets combining to stimulate it. Dairying requires for its most efficient practice a climate that is cool rather than warm and which is at the same time equable. The Puget Sound region is admirably suited to this enterprise. The combination of crops and yield made possible to feed a dairy cow for approximately ten cents a day in 1890. These conditions, and the early prosperity of the State, had resulted in many fine cows and bulls being imported so that there were herds of excellent cattle and a general high quality of stock.

The dairy industry up to the close of the century was based upon local market demands, and the supply of dairy products never exceeded the local needs. A great portion was shipped in up to 1912, so large was the stable and transient population—railroad laborers, miners, lumberjacks, sailors—and so rapid was settlement of the Pacific Northwest. The possibilities of dairying were, however, recognized and movements were beginning which would make it one of the most important branches of agriculture in Washington.

From 1900 to 1910 there was an expansion of dairying in Washington. This movement came about as a result of rapid development and increase in population, not only in the Area, but also in Alaska, as a result of mining development there, where the men looked to the country tributary to the Puget Sound for supplies.

This export demand justified the development of the evaporated milk business and the establishment of the Carnation Milk Company's plants at Kent and Mount Vernon, and of the John Agau Company's plant at Mount Vernon.

Strawberries, raspberries, blackberries, and dewberries amounted to 32,118,000 of the total 1930 production of 36,034,000 quarts of small fruits harvested. Pierce, King, Thurston, and Snohomish Counties were berry-growing centers. Truck gardening developed on the largest scale in King County, where the concentrated population, constitutes a ready market for the market-garden vegetables raised there.

One of the major developments during the period since 1910 has been the organization of cooperatives. In some departments of agriculture this has been a very important change in agricultural marketing technique enabling farmers to adjust themselves better to the complexities of modern society. In most phases of agriculture in the State, cooperatives have marked the transition from limited individual efforts to large-scale production. In marketing fruits and vegetables, cooperatives also came to play a major part during the first two decades of the present century, some forty of them handling fully one-third of the State's apple crop by 1920. Much of the dairy, poultry, and berry products of the Area are also sold through cooperatives.

A different kind of association—less purely cooperative—is the selling federation. The Northwestern Fruit Exchange, founded in 1907, played a very important part in initiating a more business-like

marketing procedure in the industry. Among berry marketing organizations the Puyallup and Sumner Fruit Growers' Association is one of the oldest, having been organized in 1902.

Some of the first soil conservation activity in Washington was the establishment of Erosion Control Demonstration projects in 1935 and the establishment of several Civilian Conservation Corps camps to aid in the demonstration work. Two such camps were established in western Washington in 1938. One of these was located at Snohomish where it functioned until shortly before World War II. Many of the agencies concerned with agriculture and other institutional factors are described in Appendix II, Political and Legislative Environment.

The Puget Sound Area has never been self-sustaining as to food production. Presently the Area imports much of its caloric intake, especially grain products, as well as meat. The Area is capable of and does produce its own dairy products, poultry, and much of its vegetables and berries.

The status of farming in the Puget Sound Area today is, of course, the result of many physical and economic factors. Soils, climate, transportation rates, rising costs, lower prices, and government regulation are prominent among these factors.

The future of farming and its economic contribution to the Area will in a large measure depend on retaining good agricultural soils in cropland use and in developing and protecting these lands for a high level of production efficiency.

PHOTO 2-1. Rye and vetch growth, 8 feet tall, being plowed under for soil improvement. Good soil management assists in sustained production. Puyallup River Basin. SCS.

PUGET SOUND AREA

PRESENT STATUS AND POTENTIAL

The Land Resource

The land area is a fixed quantity and the area of land must satisfy the diverse space needs of the region for all time. The way in which the needs of the region for living space are met will depend on how well the available land serves these needs. It will, in effect, depend on how well the land that can be used for the production of food and fiber will also serve the purposes of watershed protection, water supply and other purposes of open land, including the regulation of stream runoff.

Land in its natural condition has numerous interrelated characteristics that are the result of many centuries of conditioning to the environmental factors of climate and raw geologic material. Some of these characteristics are topography, vegetative cover, soil mantle, and related factors. Features such as mantle stability, permeability and water-holding capacity are thus in a delicate dynamic balance reached somewhat by trial and error over long periods of time, that represent the best compromise between the forces of nature. Land in its natural condition serves hydrologic purposes well. Water received through precipitation is retarded, stored, and released with minimum damage to the land from sediment movement and streamflow fluctuations. Streamflows are moderated so that floodflows are generally less and minimum flows higher.

The supply of available land ranges over a wide spectrum of elevation, topography, climate, water-holding capacity, stability, soil permeability and vegetative productivity, and similar properties. Lands, also vary widely in their ability to accept development from the natural condition for more intensive use by man. Some areas have the ability, or capability to accept given changes with minimum damage to the stability of the soil mantle or to the hydrologic cycle. Other areas are critical, and development of them may result in widespread damages within and outside the area caused by sediment movement, flooding, and swamping. Each developed area has certain minimum needs for treatment and maintenance in order to allow continued use in the developed situation. These minimum requirements are tolerable in cost in some areas and prohibitive in others.

Some changes made during development are reversible while other changes are permanent. Good judgement dictates that land be developed carefully from its natural condition so that irreversible changes are not induced in critical areas needlessly, or without full consideration of the consequences.

To achieve the objectives of planning as set forth in Senate Document 97, it has been necessary to inventory present agricultural resources. This has been done by measuring present land use through analysis of existing aerial photography, other resources by interpretation of existing standard soil survey reports, by analysis of Forest Service timber and land resource data, and by consultation with hydrologic specialists to determine availability of water.

Determination of the production levels of the farming sector of agriculture required analysis of the 1964 Census of Agriculture. Inasmuch as the Census of Agriculture does not provide production figures for land that is pastured, and the Puget Sound Area has approximately 44 percent of its arable land in pasture, it was necessary to derive a yield of forage from this type of land use.

Of the 591,500 acres of cropland, 78 percent is presently used for grass production. The long cool growing season with the long summer days of this latitude, give the Area an advantage for the production of grass. However, supplemental irrigation is desirable during three to five months to make up rainfall deficiencies and prevent dormancy of the grass. Natural precipitation is generally adequate again in September and growth continues in most of the Area until November.

The Area produces about 75 percent of the feed used by the dairy and beef industries. Much of the hay and feed grains are imported from east of the Cascade Mountains. Present economic conditions make it more profitable to utilize the grass as pasture and import the hay. Current practice is to ensile that portion of the excess grass produced in the spring months rather than to over expand the herds seasonally to take advantage of animal harvesting.

The population of the Area is adequate to provide a market for the farm production and a dairy industry has been developed which makes use of the grass an efficient and usually profitable (secondary)

enterprise on the farm. Current production is over one billion pounds of milk annually. Beef production presently uses about 26 percent of the forage produced.

Many crops are grown in the Area in addition to grass. Vegetables of many varieties are grown for the local markets, and peas, beans, corn, broccoli, rhubarb, strawberries, cane berries, and similar crops are processed in established canneries and frozen food plants.

Information derived from the 1964 Census of Agriculture indicates the present average yields of major crops grown are as follows:

Hay	2.19 tons per acre[1]
Pasture	2.31 tons per acre[1]
Silage	9.48 tons per acre[1]
Small grains	.84 tons per acre[1]
Peas	2.00 tons per acre[1]
Strawberries and cane berries	3.40 tons per acre[1]

[1] Information derived from 1964 Census of Agriculture

The arable lands of the Area are located, for the most part, in the flood plains of the rivers which flow into Puget Sound. The low plateaus and bench terrace lands have also been cleared and are arable where soils have been of a quality to sustain farming.

Fertilizer is not freely used where flooding is likely to occur or where lack of adequate drainage does not allow the soil–moisture relationship necessary for good plant growth.

In spite of the incomplete development of the farmland, its productive record is such that land sells for as much as $1,000 per acre for farming purposes.

Latest available statistics[1] indicate the present population of the Puget Sound Area is 1,870,000 persons. With an area of only 591,500 acres of arable land, the gross density of population in relation to arable land is 3.16 persons per acre. For comparison the United States as a whole has the density per arable acre of .4 person.

As population has increased, the technology put to use by the farmers has kept the production in relatively close conformity with available economic opportunity. Although potential development is far above that presently achieved, the rate of development will likely keep pace with economic opportunity as reflected in market possibilities.

[1] Economic Environment, Appendix IV, Table 3–1.

The present status of agriculture in the Puget Sound Area is the result of physical and economic factors over time. The present stage of agricultural development in the Area in relation to its capability for further development is discussed. Table 1-1 is a summary of the present land use in principal basins of the Puget Sound Area.

Much of the farmland, though fertile, has problems which need to be solved to achieve the full potential for production. Large areas are subject to periodic flooding, either from overland flow from streams and rivers, or from excessive precipitation on the land itself. Approximately 482,000 acres are in need of further improvement in drainage facilities in order to profitably use technological advances presently available. Supplemental irrigation is presently used on only a small part of the land most years.

The United States Department of Agriculture, in cooperation with the State of Washington through soil and water conservation districts, has an on-going program of technical assistance to farmers who follow conservation plans for the use of their land.

A partial list of measures or practices in use on the land, as taken from reports of the Soil Conservation Service, is given here to show the variety of measures taken by farmers to protect and develop land. Managerial, protective, and restoration accomplishments of State and Federal land administrative agencies on lands in their custody are not shown. Practice units for recreation development number 2,953, plus 1,105,300 feet of access roads. Practices for conservation cropping systems are applied on 210,600 acres. Drainage improvement practices include 7,042,000 feet of mains and laterals, and 5,790,860 feet of tile drains. Irrigation developments are: Number of sprinkler irrigation systems, 2,213; number of irrigation pit or regulating reservoirs, 319; and pipeline, 288,500 feet. Streambank protective measures have been applied on 892,500 feet; channel improvement on 459,500 feet; and dikes or levees on 1,443,790 feet. There are 1,012 farm ponds reported and 251 structures for water control. In addition, there are many practices applied by individuals that have not been reported for record purposes.

The Soil

Soil materials of the Puget Sound Area are classified in four broad categories. They are: (1) materials weathered from intrusive, extrusive, and sedimentary rocks; (2) glacial sediments; (3) lacustrine deposits; and (4) organic deposits. Soils formed

from each of these kinds of parent material have different properties.

Soil Characteristics The characteristics of a soil at any particular place are determined by: (a) physical and mineralogical composition of the parent material; (b) climate under which the soil material accumulated and the soil developed; (c) relief which influences drainage, moisture content, aeration, susceptibility to erosion, and exposure to sun and the elements; (d) biological forces acting upon soil materials, such as plants and animals living in and on the soil; and (e) length of time the climate and the biological forces have been acting upon the soil materials.

Soil texture provides a description of the amounts of gravel, stone, sand, silt, or clay according to predetermined standards, and likewise provides a practical means of approximating soil property suitabilities for many uses.

Soil structure is an arrangement of textural aggregates of the soil mass. When broken, the mass tends to break into definite shapes and forms which are described as granular, blocky, prismatic, platy, or massive. Each of these forms is indicative of soil permeability, soil stability, and root penetration.

Soil consistence is the relative mutual attraction of the particles in the whole soil mass, or their resistance to separation or deformation. The consistency varies with moisture content and the degree of stickiness and plasticity is measured when the soil is wet, and the degree of hardness or firmness when the soil is dry or moist.

Soil Classification Soils may be classified or grouped in a number of ways, depending upon the purpose of the classification. They are placed in narrow classes for the organization and application of knowledge about soil behavior on farms and fields, and for engineering uses. They are placed in broad classes, however, for study and comparison over large areas such as states, river basins, counties, continents, and the world.

Soils are placed in six different categories in the United States according to the system of classification used by the National Cooperative Soil Survey. These categories are orders, suborders, great groups, subgroups, families, and series. Of these groupings, this study is concerned with the last two, the soil series and soil phase. All classification into groups and all interpretive tables are made on the basis of series or series and phase.

Soil Series. A soil series is a group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar.

Soil Phase. A soil phase is the subdivision of a soil type or other classificational soil units having variations in characteristics not significant to the classification of the soil in its natural landscape but that are significant to the use and management of the soil. Examples of the variations recognized by phases of soil types include differences in slope, stoniness, and thickness because of accelerated erosion.

Soil Mapping Unit.—The basic unit of soil mapping is termed the soil mapping unit. The soil mapping unit is a portion of the landscape that has similar characteristics and qualities and whose limits are fixed by precise definitions. Within the cartographic limitations, and considering the purpose for which the map is made, the soil mapping unit is the unit about which the greatest number of precise statements and predictions can be made. The soil mapping units provide the most detailed soils information and are the basis for all interpretive groupings of soils. They furnish the information needed for developing capability units, forest site groupings, crop suitability groupings, range site groupings. The specific management practices and estimated yields are related to the individual mapping unit.

Soils of the Puget Sound Area The mountainous areas generally consist of shallow, stony, and rocky loams and silt loams, ranging in depth from less than six inches to more than 36 inches, overlying bedrock. The soils of some mountain areas are influenced by local glaciers and volcanic materials. Glacial soils are formed on cemented basal till, clay till, outwash or recessional moraines, and lacustrine or glacial lake materials. Those soils on glacial basal till consist of sands, gravelly sands, and cemented sandy or clay till. Those soils on outwash materials consist of sands, gravelly sands, and gravelly sandy loams ranging between six and thirty inches deep over rapidly permeable gravel and sands. Those soils on lacustrine materials consist of silt loams, silty clay loams, and clay loams 24 to more than 60 inches deep overlying either stratified sands and silts or slowly permeable, firm, platy, silty lakebed materials. Those soils on stream alluvium consist of rapidly permeable sands in the upper reaches and successively grade to more slowly permeable fine sandy loams, silt

loams, loams, clay loams, silty clay loams, and clays in the lower reaches.

While the foregoing soil descriptions apply to the Puget Sound Area, specific portions apply to each individual basin. A Generalized Soils Map in Appendix XIV, Watershed Management, Exhibit 1, shows the area distribution of soil series within river basins, and provides descriptions of soil series and tables showing acreage distribution of soil series within each river basin and watershed.

Detailed descriptions of soil series, types, phases, and mapping units with their locations are published in county Soil Survey Reports.

Capability Classes of Soils The capability classification is a grouping of soils that show, in a general way, how suitable soils are for most kinds of agriculture. It is a practical grouping based on limitations of the soils, the risk of erosion and sedimentation, and the way they respond to treatment.

Soils are classified into capability classes and subclasses in accordance with the degree and kind of their permanent limitations but without consideration of major, and generally expensive, landforming that would change the slope, depth, or other characteristics of the soil; and without consideration of possible, but unlikely, major reclamation projects.

In this system, all the kinds of soils are grouped at three levels—the capability class, the subclass, and unit. Certain judgment factors are inherent in evaluating limitations or hazards. Class II land, for example, could be called Class I in many situations; here it is classified as Class II because of a continuing hazard of flooding. The eight capability classes, the broadest grouping, are designated by Roman numerals I through VIII, as follows:

Class I. Soils in Class I have few, or no, limitations or hazards. They may be used safely for cultivated crops, pasture, range, woodland, or wildlife.

FIGURE 2-1. Illustrates typical land capability classes

TABLE 2-1. Acres of soils by capability classes in Puget Sound Area[1]

River Basin	Capability Classes							Not Classified[2]	Total[3]
	II	III	IV	V	VI	VII	VIII		
Nooksack-Sumas	42,831	116,852	98,546	240	28,972	225,952	3,093	275,752	792,238
Skagit-Samish	83,012	45,659	73,135	39	68,121	244,700	8,515	1,389,373	1,912,554
Stillaguamish	20,327	22,819	30,412	0	51,230	130,878	2,659	175,302	433,627
Whidbey-Camano	5,447	6,229	62,028	0	51,439	3,416	4,376	0	132,935
Snohomish	51,627	46,516	153,679	911	126,313	276,653	5,071	533,820	1,194,590
Cedar	13,815	14,096	146,386	664	53,589	40,414	1,237	93,734	363,935
Green	25,208	8,676	93,186	230	21,585	58,600	1,214	131,534	340,233
Puyallup	26,923	39,834	128,391	219	89,004	162,976	6,862	304,841	759,050
Nisqually	6,411	51,354	83,790	0	66,580	154,174	1,236	91,241	454,786
Deschutes	7,363	18,160	54,525	0	44,419	42,096	1,015	13,230	180,808
West Sound	20,150	105,226	282,517	138	364,228	131,276	11,980	365,872	1,281,387
Elwha-Dungeness	8,424	30,851	20,940	0	12,684	32,474	2,944	338,296	446,613
San Juan	1,284	25,667	14,891	0	46,225	22,156	1,350	0	111,573
Total	312,822	531,939	1,242,426	2,441	1,024,389	1,525,765	51,552	3,712,995	8,404,329

1 Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2 Includes national forest, national park, and major urban areas.

3 Does not include fresh water of 152,444 acres.

Class II. Soils in Class II have few limitations or hazards. Simple conservation practices are needed when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife use.

Class III. Soils in Class III have more limitations and hazards than those in Class II. They require more difficult or complex conservation practices when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife use.

Class IV. Soils in Class IV have greater limitations and hazards than Class III. Still more difficult or complex measures are needed when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.

Class V. Soils in Class V have little or no erosion hazard but have other limitations that prevent normal tillage for cultivated crops. They are suited to pasture, range, woodland, or wildlife.

Class VI. Soils in Class VI have severe limitations or hazards that make them generally unsuited for cultivation. They are suited largely to pasture, range, woodland, or wildlife.

Class VII.–Soils in Class VII have very severe limitations or hazards that prevent their use for cultivated crops, pasture, range, or woodland. They often are suited for recreation, wildlife, or water supply.

Class VIII.–Soils and land forms in Class VIII have limitations and hazards that prevent their use for cultivated crops, pasture, range, or woodland. They often are suited for recreation, wildlife, or water supply.

Areas of soils by capability classes are shown in Table 2-1, and typical locations are illustrated by Figure 2-1.

Capability Subclasses As shown above, the Roman numeral indicates the intensity of problems. The subclasses indicate the kinds of limitations within the classes. The subclasses are indicated by letters, e, w, s, and c, following the numerals to designate soil survey mapping.

Secondary subclasses are used for economic evaluations of agricultural and non-agricultural uses. Primary and secondary subclasses are shown by a combination of two letters following the Roman numeral. The dominant limitation is indicated by the first letter and the secondary condition is indicated by the second letter. Where soils have two kinds of limitations, both are needed for local use.

In the Puget Sound Area, outside the national forests and national parks, there are 3,367,704 acres of land considered to have potential erosion and sediment production hazard conditions. Likewise, there are 2,036,937 acres having some degree of wetness. These lands are tabulated by basin in Table 2-2.

Table 2-2. Land conditions by capability subclass, Puget Sound Area
(in acres)

River Basin	Subclasses 1/							Total 2/
	ew	es	we	ws	s	se	sw	
Nooksack-Sumas	73,604	253,792	11,762	136,040	35,943	5,336	9	516,486
Skagit-Samish	59,439	267,771	0	150,006	38,870	4,375	2,720	523,181
Stillaguamish	43,244	135,540	0	35,414	39,411	4,516	200	258,325
Whidbey-Camano Islands	64,120	15,782	0	20,350	21,385	10,312	986	132,935
Snohomish	164,822	301,683	0	91,911	57,209	43,229	1,916	660,770
Cedar	143,141	53,247	0	26,626	25,390	21,242	555	270,201
Green	71,873	67,430	1,961	34,717	23,871	8,847	0	208,699
Puyallup	80,223	183,743	17,415	68,077	75,933	28,818	0	454,209
Nisqually	40,413	162,669	35,143	33,483	64,636	26,354	847	363,545
Deschutes	18,507	60,314	0	21,736	46,797	16,707	3,517	167,578
West Sound	362,867	257,324	2,447	66,441	98,704	91,304	36,428	915,515
Elwha-Dungeness	44,820	31,819	0	20,818	10,860	0	0	108,317
San Juan Islands	16,669	55,416	4,595	14,728	4,749	3,069	12,347	111,573
TOTAL	1,183,742	1,846,530	73,323	720,347	543,758	264,109	59,525	4,691,334

1/ Letters for subclasses denote hazards or conditions that affect land use and treatment: e - erosion; w - wetness; s - soil.

2/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. An additional 3,712,995 acres, mainly lands in national ownerships, have been surveyed with a low intensity survey.

Capability Units—Land for general farming is subject to restrictions in use or differences in treatment needed for conservation use. Variations in production occur because of differences in soil conditions and management.

Soils of the Puget Sound Area have been grouped, according to similar problems and treatment needs, into capability units in order to condense and simplify the determination of treatment needs and estimate productivity under various levels of management.

Table 2-3 gives acreages of the various capability units, by basin. Estimates of present and potential production levels for various crops are shown in Table 2-4.

Exhibit 1, near the end of this section on Agriculture, gives descriptions of identified capability units, together with management recommendations.

TABLE 2-3. Land capability units in Puget Sound Area (in acres)[1]

Sheet 1 of 3

Capability units	Nooksack-Sumas	Skagit-Samish	Stilla-guamish	Whidbey-Camano	Snoho-mish	Cedar	Green	Puyallup	Nisqually	Deschutes	West Sound	Elwha-Dungeness	San Juan	Total
	BASINS													
II ws 02	5,704	16,519			1,679	351	3,186	60						27,499
II ws 03	15,830	27,062	689		13,887	4,038	14,179	19,864	1,411	1,180	3,778	6,297		108,215
II ws 04	7,165	36,500	16,247	1,643	23,230	3,346	4,020	1,204	715	2,386	4,131	1,317		101,904
II ws 06	12,097	2,069	3,391	2,090	12,545	6,080	3,294	3,025	3,265	3,797	10,576	810	1,284	64,323
II ws 09							529	2,770	424					3,723
II ws 12				1,063										1,063
II so 01	2,035	862			286				596					3,779
II sw 02											1,498			1,498
II sw 03				651							167			818
Class II total	42,831	83,012	20,327	5,447	51,627	13,815	25,208	26,923	6,411	7,363	20,150	8,424	1,284	312,822
III ew 01	11,486	1,600	4,691	156	12,552	7,159	591	2,177	833		54,172		1,776	97,193
III ew 03											16,927	23,760		40,687
III es 02	255	2,416	2,640		1,427				40	55	3,471			10,304
III we 16	11,762												4,595	16,357
III we 17							1,961	17,415	35,143		2,437			56,956
III ws 01	11,044	22,157	5,236		9,296	33		963	2,164	1,336	1,667			53,896
III ws 02	1,734	2,229	60						20	193	436			4,672
III ws 03	476	1,210		187				72	20		748			2,713
III ws 04											1,046	1,438	395	2,879
III ws 05		361			484	1,073	586	71	532	1,070	9,093			13,270
III ws 08	23,566	150	1,024		6,439	422		185	148	457	3,335			35,726
III ws 09	8,788	1,407	2,384	2,608	8,633	5,044	1,440	969	2,232	564	3,653		675	38,397
III ws 10	25,905	4,756	825	3,278	2,103	80	4,089	13,410	4,008	2,808	4,822	2,750	7,213	76,047
III ws 11	556										456		2,536	3,548
III ws 12	8,833	347			35		9	4,572	5,155	4,489	1,001			24,441
III so 01	6,028	6,980	5,759		4,207	15								22,989
III so 06												2,903		2,903
III so 08	6,419	1,602			247	15			1,059	7,128	830			17,300
III sw 04													250	250
III sw 09		444	200		1,093	255				60	1,132		8,227	11,411
Class III total	116,852	45,659	22,819	6,229	46,516	14,096	8,676	39,834	51,354	18,160	105,226	30,851	25,667	531,939
IV ew 03				38,114				8,235	7,720		22,782	10,067		86,918
IV ew 12	30,007	14,469		2,144	130			521	134		1,360		2,140	50,905
IV ew 14	14,422	7,689	195					15,655	16,846	6,578	16,788			78,173
IV ew 22	2,715	18,025	21,642	9,519	125,285	117,705	66,421	40,075	5,597	7,349	157,220		5,534	577,087
IV es 06	15,099	1,841												16,940
IV es 07									1,133					1,133
IV es 08		3,978			4,626									8,604
IV es 09	1,896	2,262	300		320	1,903	5,219	35	710	5,362	25,561			43,568
IV es 10				725							63			788
IV es 11													20	20
IV es 13	1,998													1,998
IV es 16									5	390	323			718
IV ws 01	221	5						282	270			1,685		2,463
IV ws 02	1,096	178						3,063	80	328	21			4,766

TABLE 2-3. Land capability units in Puget Sound Area (in acres)[1] (continued)

Sheet 2 of 3

Capability units	BASINS Nooksack-Sumas	Skagit-Samish	Stillaguamish	Whidbey-Camano	Snohomish	Cedar	Green	Puyallup	Nisqually	Deschutes	West Sound	Elwha-Dungeness	San Juan	Total
Class IV (con)														
IV ws 03		23												23
IV ws 05		235	519		640	94	65	110	18	15	78			1,774
IV ws 06	4,785	2,167	1,900	1,253	2,729	1,546	604	4,537	2,892	1,083	5,311	30	389	29,226
IV ws 07									348					348
IV ws 08											2,602			2,602
IV ws 09								853	4,249	996	1,028			7,126
IV ws 10	362	1,606	140		225	1,698	490	493	95	369	1,327	84		6,889
IV ws 11	1,090	16,076	35	4,618				58	786				1,936	24,599
IV ws 12											1,053			1,053
IV ws 13											1,224	5,228		6,452
IV ws 43		94		1,449							831			2,374
IV so 01	19,876	1,981	5,556		16,670	16,907	17,996	3,184	5		3,230	2,218		87,623
IV so 10				1,531	19			46,335	36,955	24,560	152	1,628		111,180
IV so 12								1	3,170					3,171
IV se 05	4,970	265	125	2,310	746	6,233	2,391	4,755	1,916	2,008	7,540		1,002	34,261
IV se 10											389			389
IV se 11				30					14	2,030				2,074
IV se 13					1,466			199			3			1,668
IV se 06	9										19,785			19,794
IV sw 09		2,241		335	823	300			847	3,457	13,846		3,870	25,719
Class IV total	98,546	73,135	30,412	62,028	153,679	146,386	93,186	128,391	83,790	54,525	282,517	20,940	14,891	1,242,426
II-IV total	258,229	201,806	73,558	73,704	251,822	174,297	127,070	195,148	141,555	80,048	407,893	60,215	41,842	2,087,187
V ws 21	240	39			911	664	230	219			138			2,441
Class V total	240	39			911	664	230	219			138			2,441
VI ew 21	10,154	10,735	15,541	2,572	24,603	18,112	4,774	11,940	8,886	3,585	57,979		3,735	172,616
VI ew 23											2,712	8,573		11,285
VI ew 26		2,499		9,426				428	395		10,756			23,504
VI ew 28	3,651	1,167		147	1,963			1,078	2		51		2,720	10,779
VI es 17				25									248	273
VI es 18	251								50	752				1,053
VI es 19	6,748	8,353	5,353	2,658	20,406	9,817	2,329	21,865	5,919	7,111	45,307			135,866
VI es 20	2,301	3,260	680			749	1,282	160	65	1,707	15,370			25,574
VI es 21								20	2,556	1,654				4,230
VI es 22	9	2,762	270	9,033	1,183	364					1,676			15,297
VI es 23											418			418
VI es 24											39,220			39,220
VI es 25	11	60							38	3,120	2,779		10,368	16,376
VI es 27		2,441									8,973		22,259	33,673
VI ws 02				427									79	506
VI ws 19	4,144	7,083	315		4,096	1,263	1,157	5,247	3,043		1,932			28,280
VI so 01					4,075	1,539	167	3,419	3,108	2,272	20			14,600
VI so 10	991										30	1,040	35	2,096

TABLE 2-3. Land capability units in Puget Sound Area (acres)[1] (continued)

Sheet 3 of 3

Capability units	Nooksack-Sumas	Skagit-Samish	Stillaguamish	Whidbey-Camano	Snohomish	Cedar	Green	Puyallup	Nisqually	Deschutes	West Sound	Elwha-Dungeness	San Juan	Total
	BASINS													
Class VI (con)														
VI so 12		6,761	850	5,587	1,125			3,713	3,755		4,251			26,042
VI so 13		232	130	12,308										12,670
VI so 14											19,840			19,840
VI so 16											467			467
VI so 18	346	18,658	23,700	300	27,845	6,736	5,420	16,675	11,766	8,844	65,055	3,071	3,953	192,369
VI so 19								323	297	1,938	62			2,620
VI so 21				984				272	2,276	767	3,958		761	9,018
VI se 13	235	1,239	185	6,821	14,425	50	942	528			4,459			28,884
VI se 15										40	10,511			10,551
VI se 17	131	2,871	4,206	1,151	26,507	14,959	5,514	22,741	24,284	12,178	68,379		1,274	184,195
VI se 21					85			595	140	451	23		793	2,087
Class VI total	28,972	68,121	51,230	51,439	126,313	53,589	21,585	89,004	66,580	44,419	364,228	12,684	46,225	1,024,389
VII ew 30	83	1,943	1,175							995	15,405			19,601
VII ew 31	643	780												1,423
VII ew 32											3,557	655		4,212
VII es 29	212	3,206	230	285	1,652			2,416	13,829	6,290	4,014		244	32,378
VII es 30											1,934			1,934
VII es 33										185				185
VII es 34		684									415			1,099
VII es 35	394	6,673	595			56	71				17,193		11,027	36,009
VII es 36	224,618	229,874	125,472	3,131	272,069	40,358	58,529	159,247	138,324	33,688	88,576	31,819	10,885	1,416,590
VII ws 20	2	435			502			1,313	372		182			2,806
VII so 23		1,105	3,406		2,430				1,649	938				9,528
Class VII total	225,952	244,700	130,878	3,416	276,653	40,414	58,600	162,976	154,174	42,096	131,276	32,474	22,156	1,525,765
VIII ew 39	443	504		2,042	289	134	87	114			3,157	1,765	1,013	9,548
VIII es 37											1,875			1,875
VIII es 38											156		116	272
VIII ws 00	1,839	3,373	1,548		2,311	347	395	4,062	999	122	682	779		16,457
VIII ws 22	139			1,017										1,156
VIII ws 23	400	3,770	760	543	858	84	66	398	197	460	2,674	110	166	10,486
VIII ws 24	24	151	341	99	1,308	494	378	277	40	83	2,627	290	55	6,167
VIII so 00	248	717	10	675	305	178	288	2,011		350	809			5,591
Class VIII total	3,093	8,515	2,659	4,376	5,071	1,237	1,214	6,862	1,236	1,015	11,980	2,944	1,350	51,552
V-VIII total	258,257	321,375	184,767	59,231	408,948	95,904	81,629	259,061	221,990	87,530	507,622	48,102	69,731	2,604,147
II-VIII total	516,486	523,181	258,325	132,935	660,770	270,201	208,699	454,209	363,545	167,578	915,515	108,317	111,573	4,691,334

1 Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include lands within national forest or park boundaries.

Soils listed by capability unit in Table 2-4 are typical of the capability unit and used as a basis of estimation. Capability units are rated for present average production based on experience reported by farmers and shown in column A of the Table.

Yields by capability units weighted by acres of occurrence and compared with yields derived from reports of the Agricultural Census show very close correlation.

Potential yields estimated in column B of the table are presently obtained on small but significant areas of fully developed lands. These yields are used as the potential yield for crop production by capability unit under conditions of full development and management. Gross potential thus computed was compared with projected needs as developed in Appendix IV, Economic Environment, for the years 1980, 2000, and 2020 (Table 2-15). Production estimates are within the potentials of the cropland capability, management, and development.

TABLE 2-4. Crop yields by land capability units in Puget Sound Area[1]

Typical soil type for capability unit	Land capability unit	Crops and yields: Hay, grass & legumes (Tons)		Hay, alfalfa (Tons)		Pasture (AUM)		Silage (Tons)		Small grain (Tons)		Potatoes (Tons)		Peas (Tons)		Pole beans (Tons)		Sweet corn (Tons)		Broccoli (Tons)		Straw-berries (Tons)		Cane berries (Tons)	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Giles silt loam	IIs1	2.0	6.0			4.75	14.25	6.2	18.6	0.75	1.0							5.0	7.0			3.0	7.0		
Agnew loam	IIsw2	5.0	8.0			11.75	19.0	15.0	24.8	1.25	2.5		12.5		1.25										
Ebeys sandy loam	IIsw3	4.0	6.5	5.0	8.0	9.5	15.5	12.4	20.1	1.3	2.5				1.25										
Puyallup silty clay loam	IIws2	2.5	6.0		6.0	6.0	14.25	7.7	18.6							4.0	6.0	3.0	4.0			2.0	5.0	3.0	4.0
Nooksack silt loam	IIws3	3.0	8.5			7.0	20.0	9.3	26.3	0.5	1.0	12.0	18.0					5.0	8.0						
Puget silty clay loam	IIws4	3.0	8.0			7.0	19.0	9.3	24.8	1.8	2.4				2.6			6.0	8.0	4.0	6.0		5.0		
Semiahmoo muck	IIws6	3.5	8.0			8.25	19.0	10.8	24.8			12.0	20.0	2.0	3.0	3.0	5.0	4.5	6.5						
Orting loam	IIws9	3.5	5.0			8.25	12.0	10.8	15.5	1.0	1.5				1.5									2.5	4.5
Coupeville silt loam	IIws12	3.5	5.0		4.0	8.25	12.0	10.8	15.5	1.3															
Cathcart loam	IIIes2	3.5	6.0			8.25	14.25	10.8	18.6	0.5												3.0	4.5		
Kitsap silt loam 3-8%	IIIew1	2.5	7.0			6.0	16.5	7.75	21.7													2.5	4.5		
Clallam loam	IIIew3	2.0	5.0			4.75	12.0	6.2	15.5	0.5	1.5														
Lynden loam	IIIs1	2.0	6.0		5.0	4.75	14.25	6.2	18.6			12.0	14.0									4.0	6.0	4.0	6.0
Dick loamy fine sand	IIIs6	1.0	6.5			2.25	15.5	3.1	20.1	0.5	1.0												4.5		
Giles loam	IIIs8	2.0	8.0			4.75	19.0	6.2	24.8	0.75	1.0							5.0	7.0			3.0	7.0		
Roche gravelly loam	IIIsw09	1.0	2.5	1.0	2.5	2.25	6.0	3.1	7.75	0.5	1.3														
Whatcom silt loam 3-8%	IIIwe16 &	3.0	7.0			7.0	16.5	9.3	21.7	0.5	1.0														
8-15%	IVew12																								
Kapowsin gravelly loam	IIIwe17	2.5	3.5			6.0	8.25	7.75	10.8	0.7	1.0											2.0	3.5	2.5	4.5
Puyallup fine sandy loam	IIIws1	2.5	7.0		6.0	7.75	16.5	10.0	21.7							4.0	6.0	3.0	4.0			4.0	7.0	3.5	4.5
Kline silt loam	IIIws2	3.25	7.0			7.75	16.5	10.0	21.8																
Lummi silty clay loam	IIIws3	2.5	7.5			6.0	17.75	7.75	23.2	0.75	1.0			1.5	3.0			6.0	8.0						
Sequim gravelly loam	IIIws4	1.0	5.5			2.25	13.0	3.1	15.5	0.5	1.5														
Sammamish silt loam	IIIws5	2.5	4.0			6.0	9.5	7.75	12.4											3.0	4.0				
Edmonds sandy loam	IIIws8	2.0	3.5			4.75	8.25	6.2	10.8																
Norma loam	IIIws9	2.0	5.5			4.75	13.0	6.2	10.8																
Bellingham silty clay loam	IIIws10	2.5	5.0			6.0	11.75	7.75	15.5	1.75	2.4														
Hemmi silt loam	IIIws11	1.5	6.0			3.5	14.25	4.65	18.6	0.5	1.0	12.0	17.0			4.0	8.0								
Kitsap silt loam 0-3%	IIIws12	2.5	7.0			6.0	16.5	7.75	21.7													2.5	4.5		

1 Records of Soil Conservation Service: "A" represents production under average (1967) management. "B" represents production presently obtained under best management. This level can be achieved as average under adequate management.

TABLE 2-4. Crop yields by land capability units in Puget Sound Areas[1] (continued)

Typical soil type for capability unit	Land capability unit	Crops and yields: Hay, grass & legumes (Tons)		Hay, alfalfa (Tons)		Pasture (AUM)		Silage (Tons)		Small grain (Tons)		Potatoes (Tons)		Peas (Tons)		Pole beans (Tons)		Sweet corn (Tons)		Broccoli (Tons)		Straw-berries (Tons)		Cane berries (Tons)	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Kickerville silt loam 8-15%	IVes6	1.0	5.0			2.25	11.75	5.1	15.5	0.5	1.0	7.0	12.0												
Sol Duc gravelly loam 8-15%	IVes7		4.5				10.5		13.9		1.75											3.0	3.8		
Skiyou gravelly loam	IVes8	1.75	2.25			4.25	5.25	5.4	7.0																
Shelton gravelly sandy loam 8-15%	IVes9	2.0	8.0	2.7		4.75	19.0	6.2	24.8	0.6												1.5	2.0		
Townsend sandy loam	IVes10	4.5	7.5		3.0	10.75	17.75	13.9	23.2		1.0														
San Juan gravelly sandy loam 8-15%	IVes11	0.5	1.5	1.4	1.7	1.25	3.5		4.6	0.3	0.7														
Meisler shaly loam	IVes13	2.0	4.0			4.75	9.5	6.2	12.4																
Melbourne silty clay loam	IVes16	2.0	2.5			4.75	6.0	6.2	7.0	0.4	0.6														
Sinclair shotty loam	IVew3	1.75	2.5	2.5	2.8	4.25	6.0	5.4	7.75	0.8	0.4											1.3	2.2		
Whatcom silt loam 8-15%	IVew12&																								
3-8%	IIIwe16	3.0	7.0			7.0	16.5	9.3	21.7	0.5	1.0														
Kitsap silty clay loam 8-15%	IVew14	2.0	5.0			4.75	11.75	6.2	15.5																
Alderwood gravelly sandy loam	IVew22	1.75	5.0			4.25	12.0	5.4	15.5													2.0	4.0	3.0	6.0
Lynden sandy loam 3-8%	IVs1	1.5	6.0			3.5	14.22	4.6	18.6	0.5	2.0		15.0									3.0	7.0		
Lynden sandy loam 8-15%	IVs5	1.5	6.0			3.5	14.25	4.6	18.6	0.5	2.0		15.0										7.0		
Spanaway gravelly sandy loam	IVs10	1.5	2.5			3.5	6.0	4.6	7.75	0.3	2.0														
National pumicy sandy loam	IVs12	1.75	3.0			4.25	7.0	5.4	9.3	0.7	1.0														
Indianola fine sandy loam 8-15%	IVse05	1.5	6.0			3.5	14.25	4.6	18.6	0.5	2.0		15.0									3.0	7.0		
Ragnar fine sandy loam 8-15%	IVse13	1.5	6.0			3.5	14.25	4.6	18.6	0.5	2.0		15.0										7.0		
Whidbey gravelly sandy loam 3-8%	IVsw6	3.0	7.5			7.0	14.25	9.3	18.6																
Alderwood gravelly sandy loam 3-8%	IVsw9	1.75	3.5			4.25	8.25	5.4	10.8													2.0	4.0	3.0	6.0
Pilchuck fine sandy loam	IVws1	0.75	1.0			1.75	2.25		3.1																
Puget clay	IVws5	1.0	2.0			2.35	4.75	3.1	6.2															4.0	5.0
Semiahmoo muck, shallow	IVws6	3.25	4.0			7.75	9.5	10.0	12.4	1.1	1.9														
Schooley loam	IVws7	2.5	3.0	3.5		6.0	7.0	7.75	9.3																
Koch silt loam	IVws8	3.0	5.0			7.0	12.0	9.3	15.5	0.6				1.0										1.8	
McKenna gravelly loam	IVws9	3.5	4.5			8.25	10.75	10.8	13.9																
Bellingham silty clay	IVws10	2.5	5.0			6.0	12.0	7.75	15.5																
Bow gravelly loam	IVws11	1.5	4.0			3.5	9.5	4.6	12.4	0.06	1.75														
Agnew silty clay loam	IVws13	5.0	8.0			11.75	19.0	15.5	24.8	1.0	2.0			1.0	3.0				6.0						
Bozarth fine sandy loam	IVws43	2.5	4.0			6.0	9.5	7.75	12.4	0.06															

Present Farm Economy

Major Uses of Farmland—In the Puget Sound Area, about one million acres, or approximately 10 percent of the total land area, is in farms.[1] In contrast, 45 percent of the total land area of the State of Washington is classed, according to census definition, as land in farms. This relatively low concentration of agricultural land in the Area is to be expected, since the Puget Sound Area contains the single urban-industrial complex in the Pacific Northwest. Recent decline in the amount of farmland in the Area has been associated with urban population growth and industrial expansion.

In 1964, the census allocations of farmland to major uses were as follows: (1)Cropland, 478,630 acres; (2) pastureland, 287,654 acres, (3) woodland, 211,357 acres; and (4) other land, 54,871 acres (see table 6). In that year, the central subarea contained 394,706 acres; the north had 385,878 acres; and the west contained 251,928 acres of land in farms.

Between 1954 and 1964, the total land in farms for the Area declined 18 percent; cropland declined 15 percent; pastureland declined 12 percent; woodland declined 29 percent; and other land declined 23 percent. In 1954, 68 percent of all land in farms was used for harvested crops or for pasture, while in 1964, these uses accounted for 72 percent of the land in farms. During the same period, the net shifts of land out of agricultural use represented 13 percent of the farmland in the north subarea (Nooksack, Sumas, Skagit, Samish, and Stillaguamish Basins, and Whidbey-Camano Islands); 22 percent of the farmland in the central subarea (Snohomish, Cedar, Green, Puyallup, Nisqually, Deschutes Basins); and 21 percent of the farmland in the west subarea (which includes the West Sound Basins and the San Juan Islands).

1 "Land in farms" is distinguished from "farmland."

TABLE 2-5. Acreage of land in farms, 1964 [1]

Land Use	Economic Subarea North (acres)	Central (acres)	West (acres)	Total PSA (acres)
Land in farms	385,878	394,706	251,928	1,032,512
Cropland	234,635	160,286	83,709	478,630
Pastureland	72,279	125,045	90,330	287,654
Woodland	59,129	86,038	66,190	211,357
Other land	19,835	23,337	11,699	54,871

1 Source: 1964 Census of Agriculture

2 See comparison of census data and measured acreages. Page 2-35.

PHOTO 2-2. High-producing pastureland in the Puget Sound Area. SCS.

Farm Output

Crops—Accompanying the decline in cropland in the Puget Sound Area, significant changes have taken place in the quantity and composition of crops produced. Census of Agriculture data for 1964 and 1959 show the following changes for the five-year period: (1) the production of hay declined 7 percent; (2) the production of small grains dropped 68 percent; (3) the production of vegetables increased 40 percent; (4) the production of berries increased 3 percent; and (5) the production of tree fruits and nuts dropped 60 percent. The 1964 levels of crop production are shown in table 2-6.

TABLE 2-6. Production by major crop groups, 1964[1]

Crop Group	Economic Subarea North (tons)	Central (tons)	West (tons)	Total PSA (tons)
Small grains	9,392	1,118	849	11,359
Field crops	36,429	3,500	308	40,237
Hay	171,991	66,569	58,915	297,475
Silage	229,572	105,946	40,613	376,131
Vegetables[2]	82,246	59,953	5,053	147,252
Fruits and nuts	137	1,172	235	1,544
Berries[3]	14,694	12,022	1,010	27,726

1 Source: Census of Agriculture

2 Production estimated from data on yields from Statistical Reporting Service and acreages appearing in the Census of Agriculture.

3 Includes blueberries and currants, not reported by Census of Agriculture. Additional data provided by Statistical Reporting Service.

These changes in crop production are related to the changes in the acreages of major crops harvested (see table 2-7). In the period between 1959 and 1964, the following changes appear significant in comparison to an overall decrease in harvested cropland of 11 percent: (1) the acreage of hay declined 12 percent: (2) the acreage of small grains decreased 66 percent; (3) the acreage of vegetables increased 40 percent; (4) the acreage of berries increased 2 percent; and (5) the acreage of tree fruits and nuts dropped 51 percent. These shifts reflect a change in composition and output, with increased concentration on production of vegetable, berry, and forage crops.

TABLE 2-7. Acreage by major crop groups, 1964[1]

Crop Group	Economic Subarea North (acres)	Central (acres)	West (acres)	Total PSA (acres)
Small grains	8,463	1,334	1,112	10,909
Field crops	3,114	374	273	3,761
Hay	72,255	38,485	31,163	141,903
Silage	23,809	11,826	5,504	41,139
Vegetables	30,821	11,150	1,088	43,059
Fruits and nuts	425	864	314	1,603
Berries[2]	3,965	3,998	440	8,403

1 Source: 1964 Census of Agriculture

2 Include blueberries and currants, not reported by Census Agriculture. Additional data provided by Statistical Reporting Service.

Another facet of these changes may be found in the distribution of production by area. In 1959, 52 percent of all harvested crop acreage in the Puget Sound Area was located in the north subarea, with 32 percent in the central and 16 percent in the west subareas. By 1964, the distribution of harvested cropland had become even more concentrated. The north had increased to 56 percent, the central subarea had dropped to 28 percent, and the west remained unchanged with 16 percent of the total.

These data on physical output have been converted to value of production statistics which appear in Table 2-8. These estimates were developed, using "normalized" prices, for the purpose of providing a common measure of output.[1]

It must be recognized that the use of a market-based price to measure the value of total production places limits of reliability on the derived values, especially in those cases where only a small portion of the total output is produced for sale; e.g., hay and silage crops. Noting these limitations, the value of harvested crops increased five percent between 1959 and 1964, while acreage decreased 11 percent.

TABLE 2-8. Value of production by major crop groups, 1964 [1]

Crop Group	Value of production in Puget Sound Area (dollars)
Small grains	527,000
Field crops	1,123,000
Hay	6,423,000
Silage	2,727,000
Vegetables	9,240,000
Fruits and nuts	181,000
Berries	8,316,000

1 Source: Estimates based upon Census of Agriculture and Statistical Reporting Service data.

Livestock and Livestock Products.—Three major products dominate and sustain the livestock sector of agriculture in the Puget Sound Area. These are milk, eggs, and broilers (see Table 2-9). All other livestock products have declined in importance over the last ten years. Analysis has indicated that the Area is nearly self-sufficient in the production of milk, eggs, and broilers. Exporting of these products has not been a factor of great importance.

Between 1954 and 1964, there was an increase of 52 percent in the number of eggs produced. In that same period milk production increased 30 percent, and the sale of chickens rose 108 percent.

The value of the output of livestock and livestock products has been dominated by the value of milk produced. The dairy segment of the livestock industry is responsible for a 1964 output of more than $50 million. The size of the dairy industry is reflected in the fact that 66 percent of the land in farms is utilized either for pasture or for harvested forage crops.

1 From unpublished data prepared by Economic Research Service, USDA; and "Interim Price Standards for Planning and Evaluating Water and Land Resources," Interdepartmental Staff Committee, Water Resources Council, Washington, D.C., April 1966.

TABLE 2-9. Production of livestock and livestock products, 1964[1]

Commodity	Unit	Economic Subarea North	Central	West	Total PSA
All cattle and calves	No.	140,429	129,310	53,648	323,387
Milk cows	No.	53,990	47,041	11,916	112,947
All hogs and pigs	No.	1,923	7,593	2,826	12,342
All sheep and lambs	No.	6,895	4,664	2,767	14,326
Chickens 4 months old and older	No.	1,280,691	1,195,653	537,160	3,013,504
Turkey hens kept for breeding	No.	2,115	21	2,028	4,164
Chickens sold	No.	2,002,543	10,628,306	762,343	13,393,192
Eggs sold	Doz.	17,749,167	16,933,369	7,624,661	42,307,197
Turkeys raised	No.	75,762	6,272	25,422	107,456
Milk sold	lbs.	507,888	463,942	100,131	1,071,961
Cattle and calves sold	No.	64,704	62,444	23,692	150,840

[1] Source: 1964 Census of Agriculture.

Farm Income—Aggregate farm income arising from the sale of farm products has been increasing steadily in the Puger Sound Area. In the last decade, the total value of sales increased 44 percent, reaching $120 million in 1964 (see table 2-10). The livestock sector contributed the greatest share of this growth, as the value of livestock products sold increased 49 percent over the 10-year period and accounted for 73 percent of the total value of farm sales.

TABLE 2-10. Value of farm products sold, 1964[1]

Farm Products	Economic Subarea North (dollars)	Central (dollars)	West (dollars)	Total PSA (dollars)
All crops[2]	14,186,305	14,959,288	2,628,715	31,774,308
Field crops	2,808,632	415,468	510,526	3,734,626
Vegetables	4,381,716	3,531,768	196,133	8,109,617
Fruits and nuts	4,387,557	3,835,140	352,645	8,575,342
Forest products and hortic. spec.	2,608,400	7,176,912	1,569,411	11,354,723
All livestock products	34,971,154	43,042,922	10,352,562	88,366,638
Poultry and poultry products	7,379,493	12,531,989	3,120,867	23,032,349
Dairy products	21,921,563	21,824,215	4,395,506	48,141,284
All other livestock products	5,670,098	8,686,718	2,836,189	17,193,005
All farm products	49,157,459	58,002,210	12,981,277	120,140,946

[1] Source: 1964 Census of Agriculture.

[2] Pastureland and small grains not included with crops.

For all crops, excluding forest and horticultural specialties, fruits and vegetables account for 81 percent of the value of sales.

For all livestock and livestock products, the dairy sector accounts for 54 percent of the sales.

The distribution of farm sales by subarea has changed gradually over the last decade. In 1954 the north subarea produced 39 percent of the total sales; the central subarea produced 51 percent; and the west subarea produced 10 percent of Puget Sound Area sales. In 1964, the share of the north subarea had grown to 41 percent, the share of the central subarea had dropped to 48 percent, and the share of the west subarea had increased to 11 percent. While

the overall pattern remained essentially the same, there was a tendency for some decentralization of production.

Changes in Technology—Changes in technology are difficult to measure in the aggregate since there are so many important factors which cannot be isolated. However, ratios of output per acre and output per employee are often used to indicate the changes in technology—either attributed to the adoption of improved technique, or derived from the increased utilization of non-land and labor factors of production.

Table 2-11 indicates the current levels of yield per acre for harvested crops. The general magnitude of change in crop yields in the Puger Sound Area between 1954 and 1964 is indicated by the following: (1) the yields of small grains have increased by 10 to 30 percent; (2) the yields of hay have increased between 0 and 20 percent; (3) vegetables yields have increased by 5 to 20 percent; and (4) yields in berry production have increased by 10 to 30 percent.

TABLE 2-11. Yield, production and acreage by major crop groups, Puget Sound Area, 1964[1]

Crop Group	Production (tons)	Acreage (acres)	Yield (tons/acre)
Small grains	11,359	10,909	1.04
Field crops	40,237	3,761	10.70
Hay	297,475	141,903	2.10
Silage	376,131	41,139	9.14
Vegetables	147,252	43,059	3.42
Fruits and nuts	1,544	1,603	0.96
Berries	27,726	8,403	3.30

[1] Source: 1964 Census of Agriculture, and Statistical Reporting Service.

Over the last ten years, labor productivity, or value of output per farm employee, has also increased substantially. A measure of the change in labor productivity, the value of sales per employee, shows an increase of 79 percent, or from about $3,400 per worker in 1954 to nearly $6,100 per employee in 1964.

Farm Employment—Between 1954 and 1964, the number of employees on farms in the Puget Sound Area dropped about 20 percent. This provides additional evidence of the effects of changing technology in agriculture. Increased use of capital and adoption of larger scale farming have increased the average productivity of labor. Further, the increased use of other purchased factors; e. g., fertilizer, pesticides, etc., has boosted the output per worker.

While farm employment has declined, the reduction has not matched the decline in the number of farms. The number of employees per farm enterprise increased somewhat over the last ten years. Nevertheless, changes in total farm employment have been more closely related to the changes in farm numbers than to any other single factor.

The distribution of farm employment by economic subarea (see Table 2-12) also indicates something about the character of the farm operations in these areas. The central subarea contains the greatest concentration of farm employment, with 57 percent of total Puget Sound employment. In contrast, the north subarea has 32 percent of total regional farm employment, while the west has 11 percent. Compared with data on output and land use, this provides strong evidence that farming in the central subarea is relatively more labor intensive than in the remainder of the Puget Sound Area.

TABLE 2-12. Employment in farming, 1964[1]

Class	Economic Subarea			Total
	North (No.)	Central (No.)	West (No.)	PSA (No.)
Family	4,700	5,900	2,000	12,600
Hired	1,600	5,300	300	7,200
Full time	900	1,600	250	2,750
Seasonal	700	3,700	50	4,450
Total	6,300	11,200	2,300	19,800

[1] Source: Estimates based upon data from 1960 Census of Population, 1964 Census of Agriculture, and Labor Force and Employment in Washington State.

Number of Farms—The number of farms in the Puget Sound Area has declined at an approximate rate of four percent per year since 1954 (see Table 2-13). This stands out, as it is a rate of decline nearly double that of the entire Pacific Northwest. The difference is due to losses of farmland to other uses and consolidation of farm units into more economic sizes.

TABLE 2-13. Number of farms by type, 1964[1]

Type of Farm	Economic Subarea North (number)	Central (number)	West (number)	Total PSA (number)
Field crop	41	6	3	50
Vegetable	150	129	4	283
Fruit and nut	194	352	23	569
Poultry	170	312	57	539
Dairy	1,345	874	254	2,473
Livestock	425	611	265	1,301
General & miscellaneous	2,604	4,853	1,816	9,273
Total	4,929	7,137	2,422	14,488

[1] Source: 1964 Census of Agriculture.

While declines have occurred in the number of farms of all sizes, nearly 90 percent of the reduction can be found in units of less than 50 acres. Since 1954, the annual rates of decline range from 13.7 percent for farms of less than 10 acres to just 0.5 percent for farms greater than 260 acres in size. The result has been to increase the size of the average unit from 49 to 64 acres, an increase of 31 percent.

In the ten years following 1954, some changes took place in the number of farms by major type.[1] The greatest change in farm numbers by type has been the 74 percent decline in poultry farms in the Puget Sound Area. Since poultry output has actually increased, however, the change in numbers of farms reveals a considerable trend in concentration of production resulting from consolidation and internal growth among the large production units. While the number of all farms declined 44 percent, the number of livestock farms increased 29 percent. This change represents the greatest deviation from the general trend.

The changes in number of all other classifications of farms were not significantly different from the average of all farms. These changes ranged from a 40 percent decrease in general and miscellaneous farms to a 54 percent decrease in dairy farms. By 1964 the largest classification by number of farms was the general and miscellaneous category, followed in order by dairy farms, livestock farms, vegetable, fruit and nut farms, and field crop farms.

A review of changes in number of farms by economic subarea shows the greatest absolute and relative decline has occurred in the central subarea. The north subarea has experienced a slightly greater rate of reduction in farm numbers than the west, despite the fact that the rate of decline in farmland is less for the north subarea. Thus the west, which has the largest average farm size, exhibits a lower propensity for consolidation of farms into larger units.

Rural Farm Populations—Between 1950 and 1964, the rural farm population in the Puget Sound area is estimated to have declined 64 percent. This change is related to the reduction in number of farms—the one factor which has had the largest single influence on changes in rural farm population in the Area. Other factors which affect the size of the rural farm population include: (1) the size of farm households (persons per household); (2) the proportion of farms which are located in areas classified as "rural" in the Census of Population.[2]

Utilizing data from the Census of Agriculture on the numbers of farms in 1964, and attempting to take into account the other factors mentioned above, estimates of 1964 rural farm population were developed, consistent with the definitions of the Census of Population. Total rural farm population for the Puget Sound Area was estimated to be 39,400.

It was estimated that in 1964 the rural farm population of the north subarea was 15,500, the population of the central subarea was 16,900, and the

[1] Farms are classified in the Census of Agriculture according to the major source of income from farm product sales; e.g., a poultry farm is one for which 50 percent or more of the farm income comes from the sale of poultry. Classification of farms includes the following types: field crop, vegetable, fruit and nut, poultry, dairy, and livestock. Farms are classified as general and miscellaneous if income is derived from sources other than those listed, or it sales fall within three or more categories with no one source providing a major part.

2 According to the 1960 Census of Population, urban is defined as including:

(1) Urban places—incorporated and unincorporated places of 2,500 or more inhabitants, and

(2) Urbanized areas—an urban complex containing at least one city of 50,000 inhabitants or more and the surrounding closely settled area that meets one of the following criteria:

(a) incorporated places with a population of 2,500 or more;

(b) incorporated places with a population of less than 2,500, provided there exists a closely settle area with at least 100 housing units;

(c) enumeration districts in unincorporated territory with a population density of at least 1,000 persons per square mile, and

(d) other enumeration districts which are included to eliminate small nonurban enclaves within a contiguous area which is classed as urbanized.

population of the west subarea was 7,000. Between 1950 and 1964, the rural farm population of the north subarea decreased 52 percent, rural farm population of the central subarea dropped 72 percent, and farm population of the west subarea decreased 58 percent.

Value of Output of the Farm Economy—The farm economy of the Puget Sound Area properly includes two separate stages of production—the primary output of farms, and the secondary manufacturing of farm products. The total value of output for 1963 has been estimated by developing related estimates of farm production and of food processing output derived from the Area's farm outputs. Developing an estimate of the latter segment of the total agricultural economy required a study of the input-output relationships of the Puget Sound Area's economy.[1]

The gross value of output of the farm economy was approximately $245 million in 1963. Farm production provided a gross output of $135 million, of which $95 million was sold to processing industries, $5 million was utilized in producing farm output, and $35 million was consumed in the form of final products. Processing industries produced a gross output of $210 million but $95 million of that output represents purchases from local farms. Thus, total gross output is comprised of $210 million in processed agricultural products, and $35 million in farm products utilized for final consumption.

The net value of the farm economy is represented by the value added in each of the stages of production. "Value added" represents final payment to the factors of production; it is the sum of wages, interest, rent, and profits. The net value of the farm economy was approximately $120 million in 1963. Farm production contributed $55 million in net value of output, while processing industries provided and additional $65 million.

Comparison of Census Data and Measured Acreages—Agricultural Census data deal only with farms (as defined by the Census Bureau) and do not encompass all of the land within a geographic area. The Land Usage and Development Technical Committee of the Puget Sound and Adjacent Waters Task Force is concerned with all of the land and fresh water in the Puget Sound Area. Therefore, areas measured from aerial photos were used for planning purposes. This inventory of present land use provides a base from which availability of land for change to other than present use may be determined.

The differences in acreages shown in tables based on Agricultural Census data, and tables based on measurement of photographs of the area are significant; however, to show present status, it is felt the measured areas are more useful for planning purposes. These acreages are given by basins in Table 1-1.

Present statistical servicing of the farming sector of the economy is deficient in the area of yields of lands used in the production of pasture for grazing animals. To achieve and approximation of yields that occur on these lands, a deductive study was made using Census data as the base, and interpreting these data from knowledge of customs, practices, and resources. In general, all lands were measured by use classes, and Agricultural Census data were expanded in direct proportion to cover all lands in the cropland use category (see Exhibits 4 and 5).

Table 2-14 is based on the proportionate expansion of each listed crop from the total of 459,361 acres of cropland reported in the 1964 Census of Agriculture to the 591,513 acres as measured by the Land Use Committee.

[1] See Appendix IV, Economic Environment, Puget Sound and Adjacent Waters Comprehensive Water Resource Study.

TABLE 2-14. Areas of crops[1] yield in units and value of production in 1964

Crop	Acres	Yields Per Acre	Total Production	Value (dollars)	Value of Production (dollars)[2]
Small Grains	13,010	1.04 T	13,530 T	46.39/T	628
Field Crops	4,447	10.70 T	47,583 T	27.91/T	1,328
Vegetables	54,024	3.42 T	184,762 T	62.75/T	11,594
Berries	9,926	3.40 T	33,748 T	302.76/T	10,218
Hay	156,554	2.17 T	339,722 T	21.60/T	7,338
Aftermath	(156,554)[3]	2.08 CNU[4]	325,632 CNU	15.35/CNU	4,998
Silage	51,906	9.14 T	474,421 T	7.25/T	3,440
Aftermath	(42,066)[5]	2.23 CNU	93,807 CNU	15.35/CNU	1,440
Subtotal	289,867				40,984
Nursery Products	7,132		N/A		12,440
Pasture	263,039	4.86 CNU	1,278,370 CNU	15.35/CNU	19,623
Cropland Not Used	31,475		N/A		N/A
Total	591,513				73,047

[1] Yields from areas not damaged by flooding in that year.

[2] Figures rounded to thousands of dollars.

[3] Aftermath produced on 156,554 acres of hayland.

[4] Calculated nutritional unit, see Agriculture Exhibit 5.

[5] Aftermath produced o.. 42,066 acres of the land used for silage.

Economic Analysis of Land Use—Land uses in many areas throughout the country indicate that forage production is competitive to so-called cash crops and other land uses, yet pastureland is generally assigned a far lower net income. This indicates that a method different from that now in general use is necessary for critical analysis. To determine the value of the forage to the land on which it is produced, requires the single-enterprise analysis of the overall farm operation.

It should be indicated here that it is possible in the Puget Sound Area to purchase all feeds and produce a profit from the dairy industry separate from that of the values derived from the land. A 60-cow dairy, having a production of approximately 13,500 pounds of milk per cow, will realize enough income to pay full price for the forage produced on the farm and still show a profit.[1]

To measure the effective nutrient yield of products harvested by animals or unweighed machine harvest, it is necessary to set up a new unit of measurement. This unit is named "Calculated Nutritional Unit" (CNU) and is based on tables in "Morrison's Feeds and Feeding," 22nd Edition.

The CNU is defined as one-twelfth of the yearly requirement of digestible nutrients fed in a balanced ration to a 1,000-pound beef cow (including the requirement to nurse and feed the calf to eight months of age at a weight of 475 pounds), or the equivalent—a 1,000-pound dairy cow producing 5,900 pounds of milk. From calculations shown in Table 1 of exhibit 5, the CNU is estimated to be 465 pounds of digestible nutrients per month.

This unit is used in the quantification of cropland needs in the Puget Sound Area.

PRESENT AND FUTURE NEEDS

Introduction

Land of itself has no "needs." When man enters an area, he brings with him requirements for survival and many desires; thus needs are created. In what follows, needs are taken as the necessities and wants of man. A large part of these needs are for food and fiber. The business of supplying the major amounts of these needs for food and fiber is the agriculture industry.

Agriculture is not only an industry adding important economic stature to the area, but is also the major user of land and water. The proper use of land by agriculture continually renews production

[1] See Agricultural Exhibit 5.

capacity and provides and protects generally favorable hydrologic conditions and other valuable environmental aspects associated with "open" use.

An increasing population will divert large areas of land from productive uses to urban and non-agricultural uses, and will, at the same time, increase the need for the products of agriculture. The opportunity is to use judgement and restraint to prevent diversion of the best agricultural land to other uses; and to improve the management of the land remaining in agriculture so that the industry can safely meet the need for increased production of food and fiber and yet permit the land to continue to contribute otherwise to the environment of man during the coming years.

General Considerations—It required all the thousands of years of history to produce the present world population of three billion people. In the next 30 years, the population will again double and yet will be served only by the same natural resources as today. In the year 2000, the United States will contain as many people as are estimated to have been alive at the time of Christ. Agriculture in this country has the ability to feed the people living here during foreseeable future years, but in many parts of the world hunger is commonplace and widespread famine is predicted by many because people are increasing much faster than the means to feed them.[1] In a world suddenly grown small in terms of time and travel, extreme need in any part cannot long fail to have an impact at home.

As man commences to utilize the resources of an area, his primary concern is with the necessities of life. Only after these necessities are met is there room for development of social aspects of man's environment. From this point, he is confronted with the simple but stubborn fact that his wants are infinite but the resources available to meet them are limited.

Man's ingenuity in developing methods of producing a surplus to his needs gives rise to diversification of enterprise and to trade. When this ingenuity in developing a surplus is based largely on unwise exploitation of natural resources, the eventual result is decline and failure, as was the evident fate of ancient Syria. When his organizational ability is able to match resources with his needs, his success is outstanding, as with Switzerland. Whether the failure to match resources with need is due to greed or ignorance, or both, this is to say world food problems are based not only on the phenominal population growth but also the vast wastage that has been imposed on the so-called "renewable resources" in every part of the world for thousands of years and which continue today. Resources of this kind are renewable only when used with consideration for the basic rules of use and care.

The United States has an abundance of natural resources which can be conservatively developed so that common needs for production can be met for the foreseeable future. But this country is relatively new and already resources have been sadly damaged by the same forces evident throughout the world. This wastage must now be stopped and reversed. The acts of man must enhance and improve these resources if our own needs are to be met through future years, and if we are to contribute, in any significant measure, to the ability of the agriculture of needy nations to meet their several requirements.

The public must share a large responsibility with the individual in the private enterprise of agriculture if these needs are to be met. Some of the general responsibilities shared by the individual and the public in developing and managing the agricultural industry and the resources on which it depends are grouped under the general headings of Research, Education and Information, and Legislation. Some of these responsibilities are national in scope to which the State of Washington and the Puget Sound Area owes its proportional support; others are primarily the responsibility of the State and its subdivisions; and some inevitably are the responsibility of the individual citizen, whether he be farmer or urban resident.

Miscellaneous Needs

Research—Hybrid corn—a great technological advance—required nearly a half century between initial discovery and significant utilization in the United States. Considering the lead time required for innovations to become effective, as well as the urgency, the following broad avenues of research deserve special mention.

[1] Among others, Raymond Ewell, Editor, Population Bulletin: "If present trends continue, it seems likely that famine will reach serious proprotions in India, Pakistan, and China in the early 1970's, followed by Indonesia, Iran, Turkey, Egypt, and serveral other countries within a few years, and then followed by most countries of Asia, Africa, and Latin America by 1980. Such a famine will be of massive proportions, affecting hundreds of millions, perhaps even billions of persons. If this happens, as appears possible, it will be the most colossal catastrophe in history."

A need for immediate and massive effort for development of sustenance for needy peoples throughout the world. This massive effort should among other things seek the discovery and development of new crops and other dietary sources which, combined with land development programs, may lead to eventual agricultural adequacy in these countries without further depletion of the natural resources on which these endeavors depend. This effort should include the capture and full utilization of wastes in improving depleted resources and in preventing pollution and further degradation of the environment.

Many associated research efforts are, of course, in progress but the concern is that the effort is not of a size or intensity to meet the need. This is not entirely a humanitarian effort, for the benefits in discovery of basic knowledge and development of technology would likely be sufficient to largely offset the cost and would be of great service in solving problems that exist in some degree in every country, including the United States.

Education and Information–With development of technology, fewer people are required for production of food and fiber required to support a rapidly expanding urban segment of population. This urban segment quickly forgets that their means of sustenance depends upon a healthy, flourishing agriculture, and that the majority of their food products, clothing and shelter originate on the land in forests, on farms, and in the waters originating on the land. The urban population is rapidly becoming a majority factor over the rural segment of the population. It becomes imperative that the urban segment recognize their responsiblity to continued prosperity of the Puget Sound Area by providing support equally to all segments relative to their environment and to the economy, including agriculture. This may be accomplished, in part, through education in secondary schools, news media, and service organizations.

The general public should be provided with the opportunity to become fully informed of the fact that only a fraction of Federal agricultural expenditures are actually used to support food production of the land and that the major part of agricultural expenditures are for consumer benefits; surplus food distribution to the needy, school lunch programs, processing, and transportation.

The conservation and maintenance of productivity of the land is a responsibility of the public, both urban and rural. Both must be made aware of the fact that misuse of land has serious consequences in erosion and sedimentation. Misuse of urban land during and following construction may have devastating effects by clogging stream channels, changing water quality, and causing property damage. Likewise, improper use and management of rural lands may have equally devastating effects. The public should be made aware of these land use hazards through educational sources. Only through public acceptance of its responsibility may the costly, devastating effects be reduced and eliminated.

The successful management of the land resources depends upon training and education of people in institutions of higher education in the various phases of land resource management. Training and education needs go beyond economic management. There is a need to train scientists for research relative to plants and soils and their physical, chemical, and biological behavior, and response to treatment under urban and rural uses, and in animal sciences and water management. In the Puget Sound Area, urban and agricultural uses are about equally divided, with about 6 to 7 percent in each use. However, population and land use projections indicate an increasing need for urban uses.

More food and fiber must be produced upon fewer acres of land. This can be accomplished only through education and training of people capable of conducting the necessary research. Likewise, there will be a need to educate and train people for instruction work in secondary schools, extension, and public relations for the purpose of disseminating timely technical advances to the public, in a timely way.

An annual deficit of between eight and ten thousand professional agricultural scientists accrue in agriculture on a national basis. This deficit demonstrates an urgent need to accelerate an educational program in agricultural and related sciences for the purpose of meeting future research and educational needs which are expected to increase in proportion to an expanding population.

Legislation and Policy–Agriculture is a private enterprise engaged in producing food and fiber at a reasonable price for urban consumption; it is also responsible in a large measure with protecting environmental qualities for hydrologic purposes and for esthetic and other enjoyment by the public. In order for private enterprise to do a good job of these things, it must operate under a reasonable profit motive and in an economy stabilized to the point where good

management can operate and invest in capital improvements. Good land and water resources, fully developed for efficient agricultural use, become the factory for production for future years.

Income from agriculture, in relation to that from other comparable enterprises, has for some years been insufficient to induce adequate capital investment in improvement of these resources, or to seriously compete with unplanned urban expansion on lands best suited for farm production.

In the Puget Sound Area the land used for farming is about seven percent of the total land base and this cannot be considered the future base for agricultural industry unless the present trend of unplanned urban expansion onto these lands is controlled. Since the object of comprehensive planning is, in part, the reversal of adverse trends, it seems wise to consider clarification of policy, providing agriculture a more equitable position in comparison with other uses. To this end, a need exists for definitions of policy, implemented by legislation and financial and credit assistance where appropriate, to fully recognize and protect the interests of the public as follows:

1. Provide on a continuing basis plentiful supplies of high quality agricultural products at reasonable prices, under private enterprise without degradation of the land resource.

2. Preserve, improve, and maintain environmental aspects of land and water managed under private enterprise.

3. Regulate the use and treatment of land to prevent development of any land use, faulty maintenance, or misuse of land likely to degrade the environment or result in pollution of public waters by sediment or other erosion products, or likely to cause offsite damages.

4. Regulate the use and treatment of land to prevent development for uses likely to induce excessive expenditures for public services or likely to cause excessive public costs for correction of offsite damages caused by such use.

Agricultural Production Needs

Measures needed for the development and protection of the land in agricultural use are discussed here and quantified as needs: means to satisfy these needs are discussed later in terms of feasibility and planned accomplishment.

The environmental aspects of agricultural and other uses of the land, and the effects of measures required for the protection and improvement of land, are contained in Appendix XIV, Watershed Management. Flood protection and irrigation are additionally discussed in appendices of appropriate title.

Cropland use presently requires something less than 600,000 acres, or about seven percent of the land base. If the best agricultural lands, which are located in the flood plains of major rivers and tributaries and on low benches, are protected and developed, needed production of farm products can be met. Lands for future urban development would thus come mostly from the forested areas at low elevations, and from areas presently classed as being in rural non–farm use.

The Area is projected to have a population of 2.7 million by 1980; 4.3 million by 2000; and 6.8 million by the year 2020.[1] The increase in population will greatly increase the demand for agricultural products.

Cropland Products—The Puget Sound Area has always been a food deficit area. Nearly all grain products, much of the meat other than poultry or fish, and oil seed products are shipped into the Area. The goal used here for agriculture is balanced development of the resource base in order to produce in the Area the expected proportion of regional and national production. The estimated needs for forage and small grains are tied directly to projections for the production of milk. It is assumed that if milk production is to rise 27 percent by 1980, for example, it will take 27 percent more forage measured in calculated nutritional units (CNU). This is estimated to require 4,655,800 CNU production by the year 2020. It is believed that the percentage increase in needs for field crops and nursery products will closely parallel the estimated increases in population. Table 2-15 shows the estimated cropland production needed to meet this goal.

Estimated Cropland Needs for Land

The Puget Sound Area has approximately 591,500 acres of cropland used in 1964 about as follows: for forage production (including pasture, hayland, and silage), and for small grains, 484,500 acres; field crops, 4,500 acres; vegetables, 54,000 acres; berries, 9,900 acres; nursery products, 7,100 acres; and idle land 31,500 acres.

Lands available for agriculture in future years are particularly sensitive to withdrawals of land from

[1] Appendix IV, Economic Environment.

TABLE 2-15. Estimated cropland production increases needed[1]

Crop	Est.[1] Percent Incr.	Production: In Total CNU's	In CNU's Per Ac.	In Total Tons	In Tons Per Ac.	In Total Acres
Present (1964)						
Forage & small						
grains		2,107,600	4.35			484,500
Field crops				48,800	10.85	4,500
Vegetables[2]						54,000
Berries				33,700	3.40	9,900
Nursery products[2]						7,100
Cropland not used						31,500
Total						591,500
Estimated 1980						
Forage & small						
grains	27	2,676,700	6.00			446,600
Field crops	46			71,200	13.55	5,300
Vegetables	80					77,800
Berries	52			51,200	4.25	12,000
Nursery products	46					9,900
Cropland not used						0
Total						551,600
Estimated 2000						
grains	73	3,646,100	9.25			395,200
Field crops	130			112,200	14.90	8,200
Vegetables	170					106,000
Berries	107			74,400	4.65	15,000
Nursery products	130					13,900
Cropland not used						0
Total						538,300
Estimated 2020						
Forage & small						
grains	120	4,636,700	13.25			349,800
Field crops	264			177,600	16.30	10,900
Vegetables	255					127,800
Berries	158			86,900	5.10	17,000
Nursery products	264					19,500
Cropland not used						0
Total						525,000

[1] Figures rounded to hundreds

[2] Source: Increased production needed. Appendix IV, Economic Environment.

[3] Production totals not available in other than acreage shown.

the agriculture base for urban, commercial, and non-farm purposes, including reserves for recreational and associated reasons.

Lands available for the agricultural industry consist of lands suitable for crops and land suitable for forest, less the land devoted to other purposes, such as urban and non-farm uses and lands reserved for non-productive uses. Large factors in the requirement of land for urban purposes are the density of urban development for the projected population, as well as the location of this development.

Land Needed for Urban Use—The Puget Sound Area had approximately 1,870,000 people as of 1963.[1] Of these 1,870,000 people, about 50,000 were considered farm population and 1,820,000 were considered urban.

Not allowing for any population increase since 1963, these 1,820,000 people are presently living on about 667,000 acres of land.[2] This is a population density of 2.73 persons to the acre.

The tendency toward unplanned urban and suburban growth is an enemy of efficient utilization of the land resource. This type of exploitation creates a hopscotch pattern of development and results in a greatly increased economic burden in providing transportation and other public services, and a loss of environmental quality. The alternative is to plan such developments to secure benefits that might otherwise be lost.

Alternative densities of urban development have a basic effect on land available for agriculture, recreation, and other open use. The total needs for urban use of land by selected years is estimated by the following computations based on densities of four, six, eight, and ten persons to the acre, together with future acreage needs in excess of the land presently dedicated to this use.

TABLE 2-16. Estimated increased acres needed for urban use, by population densities, and time periods

Year	Urban[1] population	Population densities per acre			
		Four (acres)	Six (acres)	Eight (acres)	Ten (acres)
1963	1,820,000	0	0	0	0
1980	2,677,000	2,250	0	0	0
2000	4,250,000	395,500	64,100	0	0
2020	6,759,000	1,022,750	372,900	117,900	8,900

[1] Regional Economics Study Technical Committee data.

People moving into the Puget Sound Area have shown a preference for suburban areas, partly in search of cheap land for development and for speculative investments. This has led to considerable urban sprawl, and a low average present density on lands classed as urban and rural non-farm.

[1] Sources: Projection from "1980, 2000, 2020—An Economic Study of the Puget Sound and Adjacent Waters Area," Consulting Services Corporation, 1967; and unpublished population projections, Washington State Department of Commerce and Economic Development.

[2] Unadjusted measurements, 1966, for Puget Sound Area, based on 1965 aerial photographs.

Public services, for example, roads, water supply, sewage disposal, streets and others, become costly on a per capita basis when population densities are low. A savings in service costs can be achieved in urban areas when densities are increased.

Urban sprawl must be controlled to provide a land base from which to compute lands available for future agricultural use. It is assumed an average urban density of six persons per acre would be suitable for gross planning land use purposes. Land requirements for urban use thus computed make it possible to estimate the loss of agricultural land to urban uses. This density is used in all basins except the Cedar, where projected population requires a density of at least ten per acre be used as suitable land is limited. Of the plans shown in section 6 only B and C_2 illustrate retention of ample lands for agricultural use. Other land use patterns similar in nature which feature adequate average density of urbanization and wise location of development may also provide a suitable agricultural land base.

Agricultural Needs for Land—To develop the expected share of farm production, a maximum of 66,500 acres can be changed from cropland to urban use.

It is assumed that by the year 2020 the demands of urbanization, commercial establishments, and recreation will have diminished the amount of cropland that will be available for continued farm use. If the loss of cropland can be held to approximately 66,500 acres, leaving a total of 525,000 acres, it will be possible to produce the quantities of foodstuffs that it is projected will be needed in the years to come.

The biggest loss of cropland acreage is expected to occur between now and 1980, as it will likely take that long to set up effective regulating ordinances. More about regulations may be found in the "Means to Satisfy Needs" section. The expected reduction during this period will be about 40,000 acres, or 60 percent of the overall loss. By the year 2000, approximately 13,000 more acres of cropland will be absorbed, even with effective regulation; and by 2020, the final 13,000 acres will be lost.

Production is also affected by the kind of land changed to urban use. These developments need to be located on the outwash terrace soils which are better adapted to urban use, thus leaving the bottom lands of the flood plains in farm production. The balance of the land needed for urban use is expected to come from the forested areas at lower elevations.

TABLE 2-17. Estimates of shifts in land use by time periods[1] (in acres)

Land use	1963	1980	2000	2020
Cropland	591,513	552,656	538,097	525,000
Rangeland[2]	106,448	106,500	106,500	106,500
Forest land[3]	7,039,184	7,013,873	6,960,432	6,732,229
Urban built-up[4]	428,330	731,300	799,300	1,040,100
Rural non-farm[4]	238,854	0	0	0
Fresh water	152,444	152,444	152,444	152,444
Total	8,556,773	8,556,773	8,556,773	8,556,773

1 Figured on an overall density for the Area of 6 persons per acre, except in Cedar Basin where density will average 8 in 2000 and 10 in 2020. (See Chapter 6, "Future Land Use.")

2 Mainly salt water marsh, open lands in high forest areas, and lands unsuited for development.

3 Including open lands associated with forest areas.

4 Estimated as all urban for 1980 and beyond.

Cropland needs for land, 525,000 acres, in relation to other uses are shown in Table 2-17.

An alternative need for land to achieve necessary production level would be to clear equivalent acres of forest land on the bench terraces, and, by intensive irrigation and fertilization at much higher cost, produce the needed food and fiber. The anticipated costs of this alternative under free enterprise would likely force crop production out of existence and deprive the area of much of this industry.

Needs for Protection and Development

Watershed Protection and Rehabilitation Measures—Soil erosion, various other aspects of land stability, and the programs and projects required to prevent excessive rates of erosion and movement of soil from land under various conditions of use are considered in Appendix XIV, Watershed Management.

The first defense needed against excessive erosion lies in choosing land so that the intended use does not exceed the land use capability of the site: the second defense is selection of treatment measures according to use. Treatment measures needed are an assortment of vegetative and structural measures selected on the basis of land use to supplement the natural defenses of the land against excessive soil loss. When the use is properly fitted within the capability of the land, the cost of treatment measures is nominal, but where the use exceeds the capability, the costs of effective protection may be excessive.

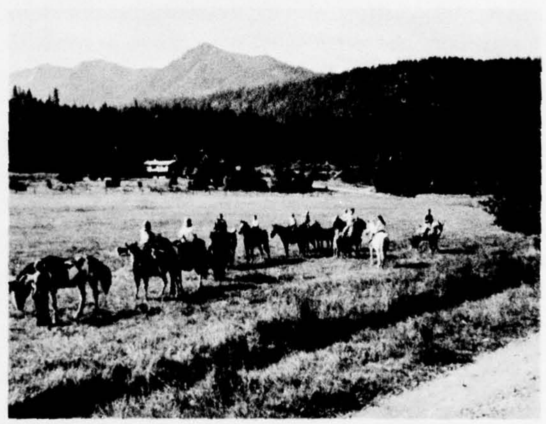


PHOTO 2-3. Agriculture furnishes many opportunities for recreation in a multiple use of the land.

The kinds and amounts of protective measures needed on lands in agricultural use are estimated from consideration of requirements estimated by capability units,[1] which are soils arranged in groups having similar requirements for protection under conditions of continued use. The use of land without necessary measures for protection leads to loss of production and rapid deterioration of the land and cannot be continued without eventual destruction of its value for agricultural and many other purposes.

1 Capability units are described and needs shown in Exhibit 1 at the end of this section on agriculture.

The costs of erosion control are properly a continuing charge against the use of the land. The full implementation of required measures is classified as a need for any use of land, including agriculture, and considered more fully in Appendix XIV, Watershed Management. Costs of installing required measures are commonly the responsibility of the landowner, acting individually or through group endeavor.

The consequences of erosion are reduced capital value and lessened productivity of the land on which the erosion occurs. Usually these considerations provide sufficient reason for the owner to install at least part of the measures needed to prevent excessive erosion.

In addition to the onsite effects of erosion, there are widespread offsite effects. Products of erosion cause sedimentation and pollution of streams, lakes, and other public waters; induce land loss, flooding, swamping, and general onsite and offsite deterioration of the environment; and thus become a matter of public concern. The widespread effects of erosion create needs for public intervention in the form of regulation of use and treatment and need for provision of other incentives sufficient to induce the individual owner to install the measures which are discussed further in the "Means" chapter.

Measures required to prevent erosion of farmed lands consist of measures to protect the surface, such as winter cover crops, tillage practices, and cover management. Intensities of practices vary with the kind of land. All conditions that are conducive to a stable, thrifty agricultural industry are generally needed to induce the private owner to make capital investments in the lands and to operate and maintain these measures at a high level. Such measures on cropland are needed on 522,656 acres in 1980; 538,097 acres in 2000; and 525,000 acres in 2020.

Need for Floodwater Damage Reduction—Major elements of stream flooding are discussed in Appendix XII, Flood Control. Environmental aspects of flooding, erosion, and drainage are contained in Appendix XIV, Watershed Management. The concern here is with the needs of agriculture for floodwater damage reduction, which may differ in kind and degree from that required for the more intensive development of the land for uses other than agriculture. The works of improvement for flood prevention consist of land treatment measures and structural measures that produce benefits to groups of landowners, communities, and the general public.

Lands best suited for cropland use lie, to a large extent on the flood plains of rivers and tributary streams. Thus they are often subject to inundation from overbank flooding of the streams, as well as to inundation from other causes, such as excess rainfall.

In this discussion, the term "floodwater" is used to refer to all forms of damaging inundation. The benefits of flood prevention are the prevention or reduction of damages to property (including erosion and sedimentation); lessening or avoiding disruption of enterprise activity and conditions hazardous to health and security; preventing loss of life; and increases in net returns from higher use of property made possible as a result of lowering the floodwater hazard. Flood prevention is taken as any undertaking for the conveyance, control and disposal of floodwaters caused by abnormally high direct precipitation, stream overflow, or floods aggravated by or due to wind or tidal effects.

Agricultural land totaling 454,400 acres needs protection from floodwater damages through 2020. Protection from such damage will avoid losses in production and will make it practical to provide improved management, including drainage and irrigation installations needed to obtain the productive potential of the land.

The degree of protection required: i.e., the recurrence interval of floods exceeding the level of protection, varies somewhat with the nature of farming operations. This needed protection, however, is considerably less than that required by urban developments.

About 80 percent of the cropland is used for growing forage for the dairy and beef industry, and indications are this use of the land may drop to about 68 percent by 2020. Grass in this area is a perennial crop, and grass in good condition provides excellent year-around protection to the land from erosion. Other lands used for short-season summer crops under conservation management are planted to winter cover crops that likewise furnish considerable protection to the land. This use of the cropland often permits occasional flooding to occur without serious loss, provided the duration of the flooding is short and the flooding occurs during the dormant season.[1]

[1] See Land Use Capability Units, Exhibit 1, near the end of section on Agriculture.

The protection of farmland from floodwater is thus a part of production economics. The business of farming requires reduction of excessive losses caused by floodwater and sediment. Suitable protection encourages development and protection of cropland. Furnishing protection in excess of that needed for agricultural damage reduction encourages farmland to be converted to other uses. Losses of an environmental nature have not generally been evaluated in monetary terms for computation of benefit-cost ratios.

Both drainage improvements and irrigation systems will require at least moderate protection from overbank flooding and sedimentation in areas where these conditions persist. The level of protection needed may increase in future years as the investment in agriculture increases. Floodwater damage must be prevented to the extent the hazard remaining does not materially exceed other risks before development becomes practical. The costs of providing flood protection benefits vary greatly with the sites and generalizations are not warranted.

Existing protective measures vary from protection against floods expected to occur in one-third of the years to nearly complete protection. Damages to agriculture as a result of flooding usually consist of the following principal kinds: crop damage, flood hazard, land loss, and property. Need is reduction of these damages to a level that will encourage development of land for full agricultural use.

PHOTO 2-4. Silted channel of the South Fork Skagit River at low stage. This was once the major discharge channel of the Skagit River and was navigable for river freight. Channel capacity is reduced by sediment and contributes to incidence of flooding.

PHOTO 2-5. Flooded feedlots cause large losses to the livestock industry and increase pollution. SCS.

Floodwater and sediment damage reduction are needed on 454,400 acres of cropland through the three time periods.

Crop Damage.—The largest use of cropland in the Puget Sound Area is growing mixed grasses and legumes for livestock. This is a perennial crop and, typically, harvested in the field by pasturing of stock. Excesses of spring yields over the needs of the stock may be harvested by machine and converted into silage. Grasses grown are mixtures of species selected to provide highly nutritious feed throughout the growing season.

Brief floods during the growing season may damage the crop with a silt deposit, rendering the growth inedible or causing spoilage. If flooding is very brief, the damage can be measured by the percentage of the seasonal growth that must be clipped and wasted. If inundation lasts more than a few hours in warm weather, the crop suffers additional permanent damage in that some of the species in the mixture are smothered; the growth that survives differs from that planned; and consequently there is a loss of nutritive production.

Flood Hazard Damage.—Most flooding occurs during the months of October through March. Flooding damage at such times may be in proportion to duration of flooding. Floods exceeding a week or ten days largely destroy the value of the perennial crop mixture and make it necessary to reseed the pasture. This induces land preparation costs and the cost of substituting feed for that lost during the considerable time required to re-establish the crop.

Where the hazard of flooding is large, it may cause considerable risk of land loss during the period of re-establishment, and again this risk may induce reluctance to cultivate the land in order to re-establish such pastures long after the economics of production indicate this should be done.

Land Loss.—Land may be lost by scouring of inadequately protected soil by moving overland flow and by streambank erosion.

Land scour is avoided by providing a thick cover of grass during the season when flooding is likely, and by various protective measures of a structural nature.

Bank erosion is the action of streamflow in undercutting and widening stream channels. In advanced conditions this results in stream meander and braiding, thus destroying large areas of good farmland. Bank erosion is accelerated by sediment accumulation in channels and by natural or man-made obstructions that increase flow velocities or direct flow toward streambanks. Sediment, in a large measure, results from erosion so that the degradation of land lacking proper care can be, to a large extent, self-perpetuating. Protection against bank erosion requires clearing obstructions from channels and protecting channel banks with vegetation and/or structural protection.

General Property Damages.—Losses to farm property are similar in nature, though usually less in intensity, than is general in more thickly populated areas. This derives from a generally lower concentration of damageable values involved in improvements and because many important farm developments are at least partly floodproofed. Typical farm property losses are to buildings, livestock, machinery, fences, roads, and similar improvements. Losses to livestock may include loss of production as well as loss and damage to animals.

Losses, while aggregating less than would be the case in a comparable flood event involving urban developments, become of great importance to the individual owner who manages a relatively large acreage. Frequent or excessive loss creates a flood hazard or threat of loss that causes management to forego production opportunities, discourages investments in needed improvements, and results in lack of maintenance and loss of production efficiency. For these reasons, flood prevention is needed on many lands as a first element of security, preceding investments for improved *drainage, irrigation,* and other management improvement.

Needs for Water Management—The following tabulation lists specific needs for development and protection of cropland in the Puget Sound Area.

TABLE 2-18. Future needs for cropland management, Puget Sound Area (in acres)

Year	Flood Prevention[1,2]	Watershed Protection and Rehabilitation	Water Management[3]
1980	454,400	552,656	201,687
2000	454,400	538,097	156,069
2020	454,400	525,000	166,218

[1] Includes overbank flooding of main streams, total area affected.

[2] See Table 2-3, this appendix.

[3] Needs by time periods to meet production requirements (needs total 523,974 acres) by 2020.

Drainage—various crops have significantly diverse requirements for drainage. These differences stem from crop requirements during the season, either in terms of tolerance to any departure from optimum drainage or to the depth and time improved drainage is required.

Some very sensitive crops are also crops that have a short growing season and perhaps a relatively shallow rooting habit. These crops are sometimes grown and harvested during summer months when added artificial drainage may not be a highly critical factor in growth. The needed improvement under these conditions is that desirable to protect the investment against chance unseasonal storm occurrences during the growing season which might cause loss of yields or quality. Crops in this category often include vegetables and crops for the fresh market that require relatively high investments in preparing the land, in seed and fertilizer, and in weeding and thinning operations, or sensitive harvest procedures. When moisture conditions go wrong, the yield or quality may suffer to the extent the crop may be a total loss. Such crops also are often grown in a highly competitive situation. Drainage improvements often enable the farmer to plant the crop somewhat earlier in the spring, thus improving competition with imported produce and increasing the income greatly. Other crops are harvested near the end of summer and benefit from drainage installations that make possible or improve harvest operations. Some of the crops are also subject to various diseases, pests, and

abnormalities of growth that are more easily controlled under conditions of good drainage.

Drainage improvement in these situations is not primarily aimed at increasing the physical growth of the crops but as an insurance against quality deterioration, harvest complications, or loss of competitive advantage with imported produce, The benefits are usually adequate to justify installation of the improved collection system on the farmland, but may be incapable of justifying the offsite improvements required to secure competent outlet conditions because such crops are typically small acreage and intermingled with other land use.

Grass grown for livestock production is an example of a crop that requires all season drainage improvement. Grass and legume crops for this purpose and mixtures carefully designed and blended to produce growth of highly nutritious feed from early spring to late fall. Some grasses have maximum growth in the early part of the season; others are better adapted to the long, warm days of summer; and others give good late season growth. These grasses require not only adequate drainage through the growing season but some degree of drainage during the winter.

Failure to provide winter drainage causes the less water-tolerant species to disappear from the balanced pasture, and makes it necessary to plow the pasture and reseed. Aside from the added cost of reseeding, this results in the loss of production during the establishment period, and may require purchase of hay or other forage to replace that lost.

Optimum drainage for cropland pasture also has other benefits. The drained condition generally increases the productivity of the livestock and removes some of the hazards to the health of the animals. Drainage reduces the compaction of the soil and associated damage to the pasture caused by heavy grazing and generally encourages deeper rooting of the grasses, thus providing greater tolerance to temporary conditions of drought and hot weather.

Considerable acreages of cropland in the Puget Sound Area have been improved by installation of drainage measures, but provide less than the degree of drainage considered optimum for the Area. While the benefits from parital drainage are significant, this degree of drainage is considered inadequate for full production potential. Acreages improved with optimum drainage exist in some of the better agricultural areas, but the percentage of wet land thus fully improved is relatively small.

Grassland, for best production, requires a moderately high degree of drainage throughout the year, an accomplishment which usually equals or exceeds the requirement for other crops. This, incidentally, offers the advantage that land drained for best production of forage has a wide latitude of use for crops other than grass and allows diversification of use when this appears desirable.

The cropland employed in forage production in the Area is about 80 percent. This has led to accepting the requirements for grass crop drainage as representative of Area needs for estimation purposes.

PHOTO 2-6. Lush cropland pasture and good livestock combine to create a thrifty dairy enterprise. SCS.

The ease of achieving adequate drainage varies widely with soil types and topographic conditons. Some sixteen drainage groupings have been identified and tabulated as to requirements according to tile depth, spacing, and other treatment, not including outlet preparation. These, in turn, have been consolidated into six groupings for cost estimation. Costs are estimated for these groups to provide basin totals. Cost derivation is explained in Appendix XIV, Watershed Management.

The benefits from drainage have been developed by comparing farm budgets before and after drainage.[1] While varying somewhat with location, land condition, and farm operation, they illustrate that the benefits from drainage are normally sufficient to allow the farmers to install drainage,

[1] Agricultural Exhibit 6.

provided flood damage is not excessive and conditions related to the economic stability of the farm unit are maintained. These benefits are sufficient to conclude that the drainage described as needed can be installed by private enterprise during the years indicated.

Of the 591,500 acres presently in cropland, about 88.6 percent—or 524,000 acres—have a wetness problem. Most of these lands are only partially drained and require more drainage to achieve potentials. Lands partly drained still have a wetness problem, and lands once drained still retain the problem of maintaining operation of adequate drainage.

The future need for cropland drainage will become acute in the next fifty years. In order to meet higher yields on less cropland, thousands of acres will have to be drained.

TABLE 2-19. Cropland needing drainage, Puget Sound Area (in acres)

Year	Cropland Acreage (by period)	Cropland Needing Drainage	Total Cropland Needing Drainage
1966	591,500	0	0
1980	552,700	216,910	216,910
2000	538,100	144,606	361,516
2020	525,000	120,503	482,019

Irrigation.—Irrigation in the Puget Sound Area differs from irrigation in arid parts of the western United States. Production of cultivated crops is possible on most arable soils in this climate, whereas such production seldom is possible without irrigation in an arid climate. While the average rainfall is ample to meet the annual moisture requirements of crops in most parts of the Area, the distribution of rainfall is seldom optimum for production even in so-called normal rainfall years. Appendix VII, Irrigation, deals with the functional aspects of irrigation. The discussion which follows is concerned with the need for irrigation in meeting production needs.

Even short periods of drought cause disruption of plant growth and have considerable effect on production and crop quality. Grass crops have a tendency to revert to a dormant condition during hot, dry periods from which they are slow to recover, even after being supplied with water. Other crops are subject to abnormalities of growth when the water supply is interrupted or lose quality because of forced maturation.

Irrigation is a management tool for improving and insuring crop production in this Area. The margin of profit between farming with and without irrigation is smaller than in arid regions where added water is an absolute necessity; but this margin of profit is generally sufficient to make the practice of irrigation profitable if water is available at a reasonable cost and properly applied. The irrigation system must be efficient, carefully operated, and used in conjunction with good conservation and farm management practices. For a variety of reasons, most irrigation will be by sprinkling.[1]

Irrigation in this Area assists in maintaining the supply of moisture available for crops at near the optimum level. In this respect, it has a purpose similar to drainage. Drainage removes excesses of water from the soil when required in order to approach optimum crop moisture supply; irrigation adds water as needed to approach optimum conditions. The same crop may need drainage in the early spring following a period of heavy rain, and irrigation at other times when rainfall fails to deliver adequate moisture. In some years when rainfall is well distributed, irrigation may give little advantage; in other years, irrigation is needed to prevent considerable production loss. It is the increased average yield resulting from predictable and consistently improved management of seed, fertilizer, and livestock or other harvest over a period of years that proves the major worth of irrigation. Irrigation makes possible or insures germination of seeds in a seasonal schedule and insures continuous plant growth and most efficient use of fertilizer. With other crops, time of maturity and quality may be more closely regulated, and, in the case of certain crops, a degree of frost damage protection may be attained by utilizing the latent heat of the water applied. Irrigation often permits better use of land according to its capability, and occasionally increases the capability of some soils for specific crops.

Farmers, processors of farm products, and urban communities are finding a need to return waste products of their operations to the land. This can be done by irrigation with less hazard to the environment than when waste is discharged into streams. Streams generally are less well supplied than the land with organisms suitable for biological activity in

[1] See Appendix VII, Irrigation, for more complete details.

assimilating such wastes. A large part of the problem in returning agricultural wastes to the land is found in the wide and even distribution of the waste materials required for optimum breakdown and absorption. The best answer in disposing of much urban effluent and agricultural wastes such as sediments, pesticides, plant nutrients, and organic materials of high biological oxygen demand, appears to lie in the use of the effluent for sprinkler irrigation after dilution, filtration, and possibly chlorination. Effluent used in this way may serve multiple purposes in irrigation, fertilization of adapted crops, and disposal of wastes. Agriculture has the potential for disposal of its own wastes and much urban waste by this means, thereby reducing environmental deterioration.

A need for further study lies in the adaptation of the means of treating, collecting, and transporting such wastes, and disposal in accord with the particular biology of the area to the mutual advantage of crops and environmental quality of the area.

Within the Puget Sound Area approximately 516,000 acres are irrigable, of which 91,700 acres of cropland are presently irrigated. It is estimated that 196,500 acre feet of water are presently used to irrigate this cropland.

By 2020, around 396,000 acres of cropland will need irrigation to achieve needed production. This is an increase of 304,000 acres over the amount of presently irrigated cropland. The amount actually irrigated will depend on future economic and other conditions.

In order to meet the yields required, the amounts of irrigated cropland and the number of acre-feet of water needed for the various years are shown:

TABLE 2-20. Cropland irrigation and irrigation water needs, Puget Sound Area

Year	Acres Irrigated	Total Acre Feet of Water Needed
1966	91,700	196,500
1980	183,175	379,230
2000	245,670	504,635
2020	396,000	816,430

According to Appendix VII, Irrigation, it is expected that only 138,000 acres will be irrigated by 1980; 185,500 acres by 2000; and 223,000 acres by 2020 unless some effective measures are taken to prevent loss of cropland to other uses.

MEANS TO SATISFY NEEDS

Introduction

Much of the world's population is in dietary distress, bordering on widespread famine, caused in part by a rapidly increasing population and in part by long sustained and continuing abuse of resources that, with good management, might furnish sustenance.

The United States is a comparatively young country and richly endowed with natural resources; yet in a very brief period of civilization, these resources have been damaged by the same sort of exploitive management found elsewhere in the world. The Nation is also experiencing a rapid increase in population that, with time, will increase national needs for products of the land. If cropland production per acre remained at 1968 levels an additional 700 million acres of cropland of a quality similar to that now in production would be needed to meet the food and fiber needs at projected levels of consumption by the year 2020. This amount of land cannot be made available.

Under these conditions, it becomes axiomatic that the resource base be protected and maintained in the highest practicable environmental condition of readiness, viability, and flexibility so it can respond to the needs of the future.

The Puget Sound Area has, in common with the Nation, shared a loss in productive potential due partly to deterioration of the land and largely to conversion of agricultural land to other uses.

Today four out of five people live in urban areas. Here they no longer are intimately confronted with the problems of production or of operation and maintenance of the land; yet they continue to be vitally dependent on its products and for many of the environmental qualities that are necessary to their welfare and enjoyment. The plentiful production of food and fiber is only one of several aspects of the agricultural use of land. These qualities under free enterprise depend on a prosperous and stable agricultural industry. Land, properly used for agriculture develops and maintains many hydrologic, recreational, and esthetic elements that are an important part of the environment.

The public—now a largely urban public—must be kept informed of the role of agriculture and continue to guide the course of agriculture by reasonable incentives and regulations in its business of producing plentiful supplies of food and fiber at reasonable prices and of protecting and improving the

environment. This matter is too important to leave to chance and the public interest must be represented in an objective and positive way. This role of the public is not new. The difference now is that the public is less directly acquainted with these problems, yet demands more in quantity and quality of products and more in the environmental aspects of agricultural land with each passing year.

The policy of the Congress has long been to encourage the industry to provide ample food and fiber for the Nation. Over a hundred years ago the policy was established of making the knowledge of better husbandry, improved seeds, and marketing facilities available to agricultural producers. This policy has been implemented during the years by a variety of programs containing incentives for more stable marketing within the free enterprise system and for developing and protecting the land resource. These policies have been considered equitable in that they benefit the preponderance of the population.

The plan presented here for agriculture is within the above policy and requires mainly a stronger and more stable intervention on the part of the public to protect and improve the agricultural base and assure these benefits to future generations.

Objectives

The Puget Sound Area has never been self--sufficient in the production of food for its population but exports considerable products of the forest.

The objective selected by this committee is to investigate and determine the present and future agricultural resource needs for the Area.

A corollary objective is to achieve by equitable investments the rehabilitation of deteriorated land resources, to improve reserve resource production capacity, and to maintain and improve environmental values. Investments for production output benefits may generally be quantified; other benefits stemming from research, increased long-term resource production capacity, protection and improvement of environmental factors, and esthetic values are joint widespread benefits and do not lend themselves to exacting economic analysis. Benefits in the latter category are, however, meaningful and supportable by logic and long experience to result in benefits considerably exceeding the costs; hence in accordance with custom are assigned a one to one ratio of benefits to costs for evaluation purposes. The costs of developing the production output level, and the corollary costs are planned to be shared by the industry and the public.

The principal needs of agriculture can be met through these several categories of action: General improvement of marketing returns, stability of markets, and research (these are widespread needs shared largely with the nation); retention of prime agricultural lands in agriculture; protection of agricultural lands from flood damage; and development of the land for agricultural production and associated environmental values.

The following abstract of the plan to achieve the single-purpose objectives of agriculture provides the essential aspects of the means to be employed in implementation:

1 Use every acre of land within its capability and treat it according to its needs.

2 Secure legislation to provide flood plain land use regulations for preservation of agricultural cropland; to clarify jurisdiction of improvement districts; to base taxes on land use; and to fix planning and regulatory authority in the State.

3 Install or maintain protection against erosion on 631,000 acres of cropland and rangelands.

4 Install or maintain protection on 454,400 acres of cropland to the extent the hazard remaining does not materially exceed other risks before the development becomes practical. Loss is limited to tolerable values by restricting development on hazardous areas.

5 Install or maintain drainage of unwanted water from 482,000 acres of agricultural land to create a more suitable environment for growing crops to meet increased requirements.

6 Install or maintain irrigation on 396,000 acres of cropland to increase production to provide the Puget Sound Area with its expected future share of national food and fiber needs. However, as shown in Appendix VIII, Irrigation, only 223,000 acres are projected to be irrigated by 2020 unless steps are taken to prevent the loss of cropland to other purposes.

7 There are 25 early action projects indicated as feasible for flood prevention, drainage, and watershed protection and rehabilitation. These projects have an estimated installation cost of $33,989,000 (1967 prices) on 633,000 acres. See Appendix XIV, Watershed Management, for presentation and analysis of program costs. In addition 28 early action projects for flood control are proposed in Appendix XII, Flood Control, having benefits of damage reduction to agricultural use of the land.

8 Develop Federal, State, and local or private funding for the early action and long range projects and conservation management programs on forest lands and croplands.

9 Provide incentives for research toward better land and water management.

10 Provide for education concerning agricultural resources, their use and management; and develop an awareness among city and rural people concerning their dependence and responsibilities in proper land use.

Research—Increases in national agricultural production needed during future years must come largely from increases in continuous production per unit of area. The goal for the Puget Sound Area is that the increased production will parallel that of the nation; although population is projected to increase at a substantially greater rate. Increases in production require high levels of production management in combination with lands of suitable capability. This production goal can be attained using a high application of presently known technology, provided the agricultural land base is largely retained, and provided economic conditions give free enterprise the incentives to invest the capital required for development of sustained production. Research and development of new technology are required, however, to keep operating efficiency compatible with the times under changing conditions. This is the same principle generally recognized as necessary for all industries.

Agricultural research and development differ to an extent from similar activity in various other industries. In many industries these activities are carried forward by individual firms in expectation of competitive advantage and consequent future profit. Agricultural research is usually of a kind that does not lend itself to competitive advantage, and thus is largely dependent on public facilities. Benefits to the public are subsequently returned through increases in quality, variety, and quantity of produce, and in reduced costs to the consumer in the marketplace.

The needs of the Puget Sound Area for research generally parallel those of the nation, in which it shares a proportion of the responsibility. National expenditures for research in 1960 approximated $120 million annually. Many indications are that the rate should be increased, not only for the sake of production but for protection and development of other values associated with the industry.

Technological advance may be said to take place by the steps of invention, innovation, and diffusion. Of these steps, the rate of invention or discovery is the most difficult to predict, for progress does not take place at a steady pace but is the result of large and small "breakthroughs" of thought. Innovation, in turn, can be described as the process of applying basic discoveries to useful purposes; and diffusion, the process of putting the innovations to widespread use. These latter processes, under certain conditions, take place more rapidly than in former years because of better communication, but remain generally less rapid in fields such as agriculture than in more closely integrated industries.

Efforts in research and development, for these reasons, should be sustained at a consistent rate well in advance of felt needs which increase at more predictable rates. These efforts depend largely on public administration, supported by a public well versed in the needs and opportunities involved.

It is impractical to list in detail the research requiring increased emphasis. The following areas seem to be of particular importance to Puget Sound Area conditions:

Crops:

1. Large dependence on forage by the prevalent livestock industry requires continued work in improving yield and nutritional value of forage (particularly with respect to tendency of grass to approach dormant conditions with loss of yields during brief dry conditions of summer.)

2. Improvements in control of insect and disease damage.

3. Improvements in weed control.

4. Management for improved utilization of production of farm crops.

5. Use of farm crops for seed production and purposes additional to food.

6. Improvements in fertilizer and water management.

7. Introduction of new crops for diversification.

Soils

1. The great complexity and variety of soils warrant much continued work in classification and treatment interpretation.

2. Large areas of federally-owned land have been covered with low intensity soil surveys, and other areas do not have adequate surveys. This work should be accelerated.

3. Investigations need to be continued in soil-water-plant relationships with regard to various crops and various stages of maturity, particularly with a view to improving yield and quality.

Pests and Diseases:

1. Improved efficiency in protection and control against disease and insect pests affecting forests, farm crops, and livestock, using safe but effective methods with less hazard of pollution or other damage.

2. Management of animal and other agricultural wastes to lessen pollution hazards; and means of lessening odors or other nuisances under conditions of close proximity to urban concentrations of population.

Agricultural Adjustments and Management:

1. Methods of achieving fair market prices for agricultural produce.

2. Methods of improving multiple uses of agricultural lands, including recreation, wildlife, and water supply.

3. Methods of evaluating environmental quality, including recreation and esthetic values, in the public interest.

4. Methods of controlling damages resulting from natural disaster, erosion, and waste.

5. Selection and improvement of species and management.

6. There is a general need for a detailed and masterful study of agriculture in terms of total coordination of production and environment and, in particular, the quantification and evaluation of so-called intangible values. The loss of such values through unplanned urban expansion should be evaluated. It appears that certain elements of systems analysis should be developed and applied in conjunction with evaluating the total effects of the industry. The ultimate responsibility for this evaluation and for proper land use, and regulation of use where required, transcend purely local forms of government and become the specific responsibility of the state working closely with local governments. Efforts to extend the limits of application of the systems approach and to perfect new techniques require research and development through all means available.

Education and Information—Research in agricultural fields depends largely on public support. A few generations ago most of the population were directly familiar with agricultural problems. Today, four out of five people live in urban centers and are physically remote from the land despite dependence on it for plentiful supplies of food and fiber at reasonable prices, and for much of their environment.

The public now largely entrusts the use and maintenance of large areas of land on which their welfare depends to others who operate the land under free enterprise. The public must understand the problems involved and regulate and support the agricultural industry by research, incentives, and regulations to the extent required. This requires widespread exchange of knowledge between the industry and the public that is facilitated by an effective information program.

Other needs associated with diffusion of research findings and development into the industry and needs related to research and development of new technology require a large and continuing supply of professional workers trained in agriculture and associated physical sciences. The numbers of such workers, and the numbers of students in undergraduate and post graduate study, must be increased to fulfill these needs. It is expected the needs will increase with increasing population and will be recognized and met by public adminstration of facilities and policies.

Legislation and Public Adminstration—Agriculture is a private enterprise engaged in producing food and fiber for urban consumption; it is also charged in a large measure with protecting the environmental quality of the watershed for hydrologic purposes and for esthetic and other enjoyment by the public. The industry must operate under reasonable conditions of profit in order to do these things, and under conditions of stability where good management is induced to invest in long-term capital improvements. Land and water resources developed for efficient agricultural use become the plant for production for future years.

Income from agriculture in relation to other comparable enterprise has not been sufficient to

induce large amounts of capital investment, nor to seriously compete with unplanned urban expansion onto lands best suited for agricultural production.

While it is obviously impractical to list here all the developments and refinements of public policy necessary to provide equitable means for achieving agricultural benefits to the Area in future years, some of the more obvious and important measures are listed.

Protection of Cropland Base.—The land area available in the past has given wide latitude to the individual for preferential use of land with little regard to effects on total environment and with little concern for mitigation of offsite damages or service costs accruing to the public. Land resources will gradually become less plentiful as population and entrepreneural activities expand. One kind of land resource—the seven percent of the land area used for cropland—can be said to be in scarce supply. Much of this land is in the flood plains of major rivers, river tributaries, and low terraces. Free preferential selection of these scarce lands for uses other than as cropland should be prevented by immediate and adequate public policy and legislation as required. These lands should be protected and should be immediately and permanently dedicated to agriculture under good conservation practices and to other open use, and to carefully selected water-based industry. Present trends indicate steady conversion of the best agricultural lands to other uses. The object of comprehensive planning is, in part, the reversal of adverse trends. If this trend is not reversed, agriculture will rapidly be displaced from much of the Puget Sound Area with loss of the economic and environmental aspects of the industry. Plenty of land is available and suitable for the many purposes of industrial and economic development of the Area. If the cropland is retained in farms, the Area will have the advantages of both the commercial and the agricultural industry, together with other values.

Efforts of minor governmental subdivisions of the State appear inadequate to undertake the detailed and technical classification of the land and its use; the regulatory and legal aspects; and the firm and objective administration of the dedication required. The State, coordinated with local interests, appears to be the governmental body best suited to undertake this effort.

The treatment of land—under various uses should be such as to prevent deterioration, erosion, and offsite damages caused by sedimentation, swamping, flooding, pollution, hazards to health and public welfare, and similar damages. The regulation of land use, and the minimum treatment required to prevent deterioration under the various uses, should be under the purview of the State on non-Federal lands, in cooperation with governmental subdivisions and in the public interest. These powers should extend to cover all uses of the land for farmland, forestry, other open use, and municipal use.

The 1968 Amendment—to the State Constitution, permitting legislation to tax lands according to present use, should be utilized to encourage permanent dedication of suitable lands to agricultural purposes.

Co-sponsorship of improvements.—Many landowners require group enterprises to construct community drains, flood prevention facilities, and other improvements. The planning, securing of rights-of-way for construction, maintenance, and the financing of such needed improvements becomes a serious and difficult burden in many localities and beyond the reasonable effective ability of drainage districts, soil and water conservation districts, flood control districts, various local improvement districts, and subdivisions of government. The difficulties are such as to prevent needed improvements or to cause inordinate delays, expense, and hardship.

a. It is proposed that the State, upon petition of such groups, undertake and expedite securing of needed rights-of-way, when in the public interest, in the same manner as for transportation purposes. This action would include legal procedures as required and payment of damages for lands taken on behalf of the State.

b. That the State, by agreement and in cooperation with local interests, act as their agent in agreements with the Federal government in planning, construction, adminstration of contracts, and subsequent maintenance of the completed work.

c. That the costs of these services be shared, by agreement with local interests, in the form of loans and grants from State sources, such as revolving funds or monies appropriated for such purposes.

d. That the State undertake a long range study of agriculture in its production and environmental aspects, utilizing systems analysis and quantification of intangibles insofar as possible, with the purpose of establishing a permanent policy of land use regulation and treatment in the public interest.

Provision for Land Needs—The plan provides for urban use of 66,500 acres now in cropland. This

will leave 525,000 acres in permanent cropland. Land use regulation by legislative action and price and tax incentives are required to protect this resource base.

The need for land for urban development will be met by using most of the land presently classed as rural non-farm, the 66,500 acres of present cropland, and approximately 306,000 acres of forested area. This is based on an average density of six persons to the acre, except in the Cedar Basin where a density of ten was used.

Provision for Protection and Development of Land.—Under the plan landowners and operators are expected to install land treatment practices to reduce erosion to acceptable limits. The plan provides for cost sharing on practices where benefits accrue to other than the landowner.

Measures required to prevent erosion of farmed lands consist of crop rotations to maintain water intake rates and water-holding capacities of the soils, and measures to protect the surface such as winter cover crops, tillage practicies, and cover management. Watershed protection and rehabilitation practices will be applied on 525,000 acres of cropland and 106,000 acres of rangeland.

Provision for Flood Prevention—The plan provides that floodwater damage reduction to levels required for agricultural use shall be established on approximately 160,000 acres of cropland under the multipurpose early action program of structural measures. The long range program provides for additional flood prevention works to be installed during the 1980-2000 and 2000-2020 time periods to bring 454,400 acres of farmlands under adequate protection.

Provisions for Drainage Improvement—The plan provides that adequate outlet facilities be installed as part of the multipurpose early action program, and that further drainage outlets will be installed under projects proposed for 1980-2000 and 2000-2020 to provide all necessary outlet facilities.

Drainage practices, such as laying of tile and other types of onfarm drainage facilities will be installed by individual owners and operators under profit incentives as market conditions warrant. Total acreage to be developed with drainage improvement will be 482,000.

Irrigation Development—The irrigation of cropland will proceed under individual initiative or group enterprise on the profit incentive basis. There are at least two potential projects that could be developed under Federal auspices. The total cropland to be irrigated by 2020 will be 396,000 acres. However, as shown in Appendix VII, Irrigation, only 223,000 acres are projected to be irrigated by then, unless steps are taken to prevent the loss of cropland to other purposes.

Level of Planning—The foregoing plan, as prepared by the Agricultural Subcommittee of the Land Usage and Development Committee, is designed to furnish the future population of the area with an agricultural community in accordance with the natural environment and without unwarranted destruction of the environment. Alternatives to the plan are in degree only. The plan for the development of agriculture is based on projected future needs for food and fiber and is not designed as a means of injecting stimulating measures on the general economy, but its implementation will contribute materially to the stability of the economy.

IMPLEMENTATION OF THE PLAN

The implementation of this plan for agriculture depends on its acceptance by the public. For the amount of land to remain in agriculture, as this Committee recommends, the decision to reserve it to this use must be made soon. Failure on the part of the State to make any decision will automatically permit unplanned urban-type developments to irreversibly change these lands to other uses. A firm and permanent reservation of the suitable bottom land and bench terrace land for cropland and other open use will assist in stabilizing tenure and induce improvements for production in future years. Interested individuals and groups must enjoin the legislature to pass necessary legislation to this end.

Reduction of Floodwater Damage

The first increment in the development of the Puget Sound Area is that of reducing high levels of damage on lands subject to flooding by overbank flow or excessive direct precipitation.

Protection of watershed lands from floodwater damage is achieved by installation of land treatment measures and structural works of improvement. Various types of improvement practices are used, depending upon the degree of protection desired, the type of damage being suffered, and the comparative benefits to be realized.

The significant Executive Order 11296, dated August 10, 1966, recognizes the hazards of locating intensive developments in hazardous areas and the great and accumulating expense of furnishing adequate protection to these developments when

located in such areas. The order directs Federal agencies directly responsible for construction of Federal facilities and Federal agencies responsible for the administration of Federal grant, loan, or mortgage insurance programs, involving the construction of buildings, structures, roads, or other facilities, to evaluate flood hazards in connection with such facilities, and, insofar as practical, preclude the uneconomic, hazardous, or unnecessary use of flood plains in such connection.

Agriculture, in common with other developed uses of land, suffers from inundation resulting from floods of large and small streams and from accumulations of water resulting from excess precipitation and other vagaries of nature. The amount of land in the Puget Sound Area particularly subject to damages of this nature is a small percentage of the total, but this land is the part of the total land base generally best adapted to farming purposes.

Agriculture will require the continued use of much of the land presently in productive use. These lands must be provided with generally improved managment involving considerable capital investment. Croplands, in particular, lie in the flood plains of rivers and tributaries where soils and topography are suited for farming. In order to attract needed investments for drainage, irrigation, and similar improvements, a higher degree of protection than is now in place must be provided.

The minimum level of protection generally furnished to areas of intensive development is the protection from flood occurrences having a statistical probability of recurrence interval of once in a hundred years. Higher levels of protection are desirable in some circumstances.

In the Puget Sound Area the amount of land highly susceptible to flood hazard is small (about eight percent), and the total area of land suitable for intensive development is high. Good judgement generally indicates that lowlands be retained in the agricultural use to which they are well suited, and that intensive development of land, except for appropriate water-oriented industry, be located on less hazardous sites. The net result of such judgment is that this arrangement would allow the area to retain the economic and environmental benefits of a thrifty agricultural industry without hindering the development of the industrial sector of the economy. Further, these enhanced benefits would result contemporaneously with large savings in costs required for alternate development and protection of intensive use on adverse sites.

Flood Control—"Flood Control" is the term used in alleviating damages caused by overbank flow of rivers. Works of improvement are usually major flood control dams, levees, or channel improvement. The level or degree of protection provided by works of improvement has an effect on land use. Whereas a degree of protection to control all flows estimated to have a recurrence frequency of 10-25 years is considered adequate for agricultural damage reduction in the Puget Sound Area, unusually high levels of protection on agricultural lands tend to encourage a change of use from agriculture and other open uses to urban. Appendix XII, Flood Control, states that present protective facilities generally protect agricultural lands against the 2 to 8-year frequency flood event. As a result, much agricultural land is subject to frequent over-bank flooding during the winter season.

The basin flood control plans for the 1980 level of development provide for 603,000 acre-feet of flood control storage; 92 miles of levee to be constructed; and 35 miles of river channel to be improved. Approximately 211,000 acres of flood plain require flood plain managment. By the year 2000, an additional 374,000 acre-feet of flood control storage would be provided; 35 miles of additional levees and 12 miles of channel improvements would be contructed; and flood plain management would be required for 126,800 acres of flood plain land. By the year 2020, flood protection for the area would required an additional 334,000 acre-feet of storage and 40 miles of levee construction. Approximately 107,000 acres of flood plain will require flood plain management. Features of the plan are detailed in Table 2-5, Appendix XII, Flood Control.

Flood Prevention—Flood prevention is any undertaking for the purpose of reducing or preventing all forms of damage from inundation (including erosion and sedimentation) of property, disruption of business and other activity, hazards to health and security, and loss of life; and increases in the net return from higher use of property made possible as a result of lowering the flood hazard. Flood prevention is any undertaking for the conveyance, control, and disposal of surface water caused by abnormally high direct precipitation, stream overflow, or floods aggravated by or due to wind or tidal effects.

Representative treatment measures as a part of

watershed management are described in Appendix XIV, Watershed Management. Proper application of these measures protects the land and water resources from excessive deterioration, generally protects and enhances environmental values, and serves to increase production, as well as achieving a variety of other economic benefits. Some of the required measures are relatively permanent, once installed, while others require periodic renewal, and all require careful maintenance to insure effectiveness.

Installation of new improvements and more intensive application of practices are required to reduce flood water and sediment damages, improve water management, and provide rehabilitation and protection of watersheds. There are many individual measures for watershed treatment that are applied in combinations and intensities that vary with the capability of the land for specific uses as well as with degree of utilization. The total acreage requiring treatment thus remains fairly constant, while the composition of measures and the intensity of application required vary over the course of time.

Other Measures

Land treatment measures and improved management measures, such as drainage and irrigation for increased production, will be installed by owners and operators under existing incentives. Mainly, this is the profit motive taking advantage of economic possibilities to increase production at lower cost, but does not preclude cost sharing on some erosion prevention practices when benefits accrue to the public.

These activites create a continuing requirement of public and private funds to install and maintain these measures. Land administrative agencies of the Federal and State governments are responsible for these costs on lands in their custody, while private owners are responsible for most of the costs on private lands. Various agencies of the State and Federal governments maintain programs of technical, financial, and credit assistance for individuals, local organizations, and subdivisions of government in accomplishing needed work. The soil and water conservation districts serve this effort by coordinating and facilitating the utilization of available programs of assistance by individuals and local organizations in the Area.

Coordination of Construction

Flood prevention projects of the United States Department of Agriculture will be coordinated with flood control projects of the United States Army, Corps of Engineers, as per memorandum of understanding dated September 23, 1965. The two types of projects are often complementary in action on lands of the flood plain subject to over bank flooding of the main rivers. Flood control storage dams or levees on the main river may result, in reduction or elimination of overbank flooding of the main river, and the flood prevention project will deliver into the stream ponded or other excess surface flows causing damage to crops and property on the flood plain. Coordination in planning and construction of measures for both types of projects will result in savings of structural costs and increase benefits from the project.

This plan for agriculture would implement the previously mentioned national policy. Initially, the plan will be implemented by an early action program. This early action program provides for construction of 25 multipurpose projects, primarily for flood prevention and drainage, proposed in Appendix XIV, Watershed Management, in conjunction with 28 projects for flood control, as proposed in Appendix XII, Flood Control. It is planned that basin-wide authority for implementation of these projects for flood prevention would be sought from Congress so that concurrent installation of land treatment and structural measures can be accomplished. This will achieve maximum benefits from interrelated structural works of the combined programs.

A summary of the early action projects for the Department of Agriculture is presented in Tables 2-21 and 2-22. These projects are presented in more detail in Appendix XIV, Watershed Management.

Expected Production Benefits

The minimum level of floodwater damage reduction considered for cropland is such that the hazard remaining after protection does not materially exceed other natural risks or loss. This is often the 10 to 25-year frequency of flood occurrence. Floods of this frequency or greater magnitude usually occur during the winter months. The proposed level of protection is expected to reduce damages to cropland pasture by 85 percent and other damage classes by approximately 60 percent, for an annual damage reduction of $18.25 per acre.

These projects will provide needed flood prevention to 160,000 acres and drainage outlet facilities for 189,500 acres by 1980. These projects will be

TABLE 2-21. Costs and benefits of early action projects recommended for installation by 1980.

Map No.	Basin and watershed	Project area	Cost of project 2/	Flood-water protec-tion	Drain-age improve-ment	Total annual flood protection and drainage benefits	Average annual floodwater and drainage cost 3/	Benefit cost ratio
		(acres)	(dollars)	(acres)	(acres)	(dollars)	(dollars)	
	NOOKSACK-SUMAS BASINS							
10-4 1/	Middle Tribs. Nooksack	6,750	986,000	3,199	4,582	131,230	55,048	2.4 : 1
10-6	Fishtrap-Bertrand Creeks	23,914	1,854,000	13,159	13,508	435,615	103,654	4.2 : 1
10-7	Wiser Lake Area	38,305	2,448,000	14,791	18,832	566,189	137,399	4.1 : 1
10-8	Lower Nooksack Tribs.	19,835	2,370,000	10,499	12,559	377,821	134,776	2.8 : 1
11-3	Sumas River	33,079	1,241,000	14,509	14,692	461,576	68,137	6.8 : 1
0-1	Dakota Creek	20,314	430,000	593	3,118	67,992	23,281	2.9 : 1
0-4	California Creek	14,192	471,000	1,397	3,500	87,761	25,603	3.4 : 1
0-5	Silver Creek	10,866	1,173,000	2,736	4,999	141,066	66,302	2.1 : 1
	Total	167,255	10,973,000	60,883	75,790	2,269,250	614,200	3.7 : 1
	SKAGIT-SAMISH BASINS							
9-8	Gages Slough	14,419	1,107,000	9,520	7,087	243,519	60,919	4.0 : 1
9-10	South Mt. Vernon	32,132	1,434,000	9,619	10,501	322,408	80,630	4.0 : 1
0-14 1/	Samish River	63,716	4,862,000	23,859	24,028	754,678	271,712	2.8 : 1
0-15	Skagit Flats	41,148	3,234,000	31,788	28,402	921,228	180,290	[illegible] 1 : 1
	Total	151,415	10,637,000	74,786	70,018	2,241,833	593,551	[illegible].8 : 1
	STILLAGUAMISH BASIN							
0-21 1/	Lower Stillaguamish	8,522	980,000	5,547	5,422	171,737	54,272	3.2 : 1
0-22	Church Creek	8,060	665,000	2,732	4,424	116,112	37,325	3.1 : 1
	Total	16,582	1,645,000	8,279	9,846	287,849	91,597	3.1 : 1
	SNOHOMISH BASIN							
8a 1/	Patterson Creek	12,451	392,000	667	1,426	32,978	21,282	1.5 : 1
8-4 1/	Snohomish Estuary	25,759	2,111,000	12,321	10,222	363,787	120,753	3.0 : 1
	Total	38,210	2,503,000	12,988	11,648	396,765	142,035	2.8 : 1
	CEDAR BASIN							
0-27	Swamp,Bear,North Creeks	44,795	1,165,000	5,963	3,826	134,634	63,501	2.1 : 1
0-30 1/	Evans Creek	28,800	1,015,000	3,348	3,620	107,229	55,399	1.9 : 1
	Total	73,595	2,180,000	9,311	7,446	241,863	118,900	2.0 : 1
	PUYALLUP BASIN							
7-1 1/	Algona-Pacific	6,457	594,000	1,688	1,444	53,756	32,934	1.6 : 1
7-3 1/	Clear Creek	8,060	1,901,000	2,364	6,587	135,302	104,621	1.3 : 1
0-38	Hylebos Creek	16,000	642,000	2,376	1,258	50,005	34,278	1.5 : 1
0-39	Wapato Creek	6,407	979,000	3,243	1,699	68,575	53,908	1.3 : 1
0-40 1/	Clover Creek	88,092	856,000	4,990	805	74,320	45,421	1.6 : 1
	Total	125,016	4,972,000	14,661	11,793	381,958	271,162	1.4 : 1
	WEST SOUND BASINS							
0-54	Goldsborough Creek	38,501	779,000	3,388	261	4/ 48,329	41,888	1.2 : 1
0-73	Chimacum	22,326	300,000	3,375	2,717	101,596	17,327	5.9 : 1
	Total	60,827	1,079,000	6,763	2,978	149,925	59,215	2.5 : 1
	GRAND TOTAL	5/ 632,900	33,989,000	187,671	189,519	5,969,443	1,890,659	3.2 : 1

1/ Part of the watershed.
2/ Base: 1967 prices.
3/ Amortized at 4-5/8 percent for 100 years.
4/ Contains $8,000 average annual benefit to industrial areas.
5/ Acreages are unadjusted results of map measurements.

TABLE 2-22. Structural measures in early action projects

Watershed Map Number	Watershed Name	Channel Improve. (mi.)	Modification of Existing Protective Works (mi.)	Outlet Struc. (no.)	Water Storage Facil. (no.)	Debris Basin (no.)	Flood-water Protection (acres)	Drainage Improve. (acres)
0-4	California Creek	13.8			1		1,397	3,500
0-4	Dakota Creek	18.0					593	3,118
10-6	Fishtrap-Bertrand Creeks	37.0	6.0	2			13,159	13,508
10-4	Middle Tribs. Nooksack	6.7	5.0	1			3,199	4,582
10-7	Wiser Lake	29.0	10.1	4			14,791	18,832
10-8	Lower Nooksack	18.9	9.3	5			10,499	12,559
0-5	Silver Creek	16.0	5.0	1			2,736	4,999
9-8	Gages Slough	17.0		1			9,520	7,087
9-10	South Mt. Vernon	21.5		4			9,619	10,501
0-21	Lower Stillaguamish	17.0	1.0	3			5,547	5,422
0-22	Church Creek	8.4	1.0	3			2,732	4,424
8-4	Snohomish Estuary	15.0	11.0	3			12,321	10,222
0-27	Swamp, Bear, North Creeks	24.0		2			5,963	3,826
0-30	Evans Creek	16.0		2			3,348	3,620
0-38	Hylebos Creek	7.0		1			2,376	1,258
8a-1	Patterson Creek	8.0					667	1,426
0-39	Wapato Creek	7.0		1			3,243	1,699
0-40	Clover Creek	14.0					4,990	805
7-1-1	Algona-Pacific	12.0					1,688	1,444
7-3-1	Clear Creek	21.0					2,364	6,587
0-54	West of Shelton	5.0			1		3,388	261
0-73	Chimacum Creek	16.0		8		1	3,375	2,717
0-15	Skagit Flats	43.0	5.0	5			31,788	28,402
0-14	Samish Riv.	65.0		5			23,859	24,028
11-3	Sumas River	22.0				1	14,509	14,692
TOTAL	Puget Sound Area	478.3	53.4	51	2	2	187,671	189,519

installed under existing or improved cost sharing, with the Federal or State government bearing a share of the cost.

It is presumed that the first increment of a development program to meet the needs will consist of flood damage reduction measures. These measures alone are estimated to increase production, through reduction of damages and hazard, to seven CNU's, or to 3.25 tons of hay per acre.

The benefit per acre from drainage development was determined by crop budgets, adapted to current average conditions. Inasmuch as 80 percent of the cropland is used for forage production, crop budgets for forage production were considered as representative of the net income. The present average forage production per acre in the Puget Sound Area is 2.33 tons of hay, or equivalent, or five CNU's per acre when pastured.

The present production cost of hay on undrained protected lands, as indicated from adapted crop budgets (see exhibit 6) is approximately $30 per acre. This 1967 cost is converted to adjusted normalized prices (ANP) by a conversion factor of .94, and equals $28.25. The gross value of forage production is weighted by the percentage value that hay, silage, and pasture are of total forage production within the Area.

Experience shows that when land is drained, the yield will average 4.65 tons, or ten CNU's. The production cost per acre will increase due to the cost of installing on-farm drainage facilities and the addition of fertilizer and other practices needed for optimum management. The production cost on drained land is estimated to be $42 per acre (ANP), plus the cost of drainage facilities and operation and maintenance, amounting to $16.15. The annual cost of drainage is computed as the amortized cost of installation of the average of drainage groups for the watershed.

Gross income is weighted in the same manner as income under the undrained condition. The differ-

ence in net income between the undrained and the drained condition is considered as a benefit to drainage. The average benefit attained is $16.10 per acre.

Irrigation is expected to increase the average yield of pasture by three CNU's. As shown in Exhibit 7, this results in a net income of $9.05 per acre over and above all associated costs.

Impact of Plan

This report is concerned with planning the role of agriculture in the Puget Sound Area through the year 2020 and the agricultural plan advanced here seems the best. However, the future does not end in 2020. Man can make extravagant plans and be reasonably sure many of the advances will occur; the difficulty is in placing these things in a time frame.

We can plan that in some future year all foods and fibers may be totally synthetic. This could be true but in between many people are hungry. Extending trends is a risky business, as has been shown by many writers.[1]

In this setting the plan for agriculture offers very worthwhile advantages, those of flexibility. It offers more than this; flexibility without serious inconvenience to the needs of any segment of the population foreseen between now and 2020. It suggests mainly that good land be kept in agriculture; that other developments be on the ample area not suited for cropland but excellent for many purposes; that the cropland be developed to retain a share of the national agricultural production in the Area. This plan retains and develops agriculture as a viable industry in addition to the projections of other economic growth, and the valuable environmental and esthetic elements of open land are sustained at little cost to the public because the agricultural industry largely pays for the operation and maintenance.

In the face of uncertainty built into the best of projections agriculture offers flexibility for it is open use of land, and subject to other use development if the future demonstrates a vital need for such development, or if food, recreation and environmental values can be synthesized from some other source. The plan presented here appears to offer real advantages through the year 2020 and beyond by virtue of its conservative nature.

In this context a need exists for future planning—a continuing process of planning. But planning must be participated in by the public and be assisted by the best technical knowledge of all branches of physical science if it is to produce best results.

The implementation of this plan will have far reaching impact on both the social and economic character of the Puget Sound Area. The plan provides for development of the urban industrial sector to accommodate 6.8 millions of people in a setting of adequate open space. The open use of the more productive land allows farming and forestry to prosper and add to the economic stability of the area.

Planned development of the area at an average density of six persons per acre for land in urban use provides enough density to support the usual facilities in the way of streets, sewage disposal, water supply and power supply at nominal cost to residents, and at the same time provides enough space to avoid overcrowding.

The esthetic value of the Puget Sound Area will be preserved by this plan and afford wholesome living opportunity to the future residents.

The plan provides for enough farmland, when fully developed, to satisfy needs based on maintaining the present share of national production in relation to increased national population by 2020 and provides for special needs for industrial and urban development during the same time period.

[1] Among others Norman V. Peterson, American Institute of Planners Journal (1962).

Exhibit 2-1. Land Capability Unit Descriptions.

Land Capability Unit IIws02 (IIw1) consists of deep, medium, and moderately fine textured, slowly and moderately slowly permeable soils on bottom lands and river flood plains.

Management problems are wetness and maintenance of soil productivity. Flood prevention and improved land drainage make these soils well suited for growing hay and pasture, row crops, vegetables, forage, and small grains. The soils are suited for continuous cropping with the use of winter cover crops and green manures. Also, they are suited for growing hay and pasture 3 to 4 years, followed by strawberries 3 to 4 years; or hay and pasture 5 to 10 years, with row crops 1 to 2 years. Such areas, protected to reduce flood damage to a minimum, and provided with adequate drainage, will produce high crop yields under a high level of management. Moderate water intake rates and water-holding capacities make these soils well suited for supplemental irrigation. Some crop yields are materially increased by irrigation during periods of low precipitation that might otherwise interrupt growth.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Puyallup sicl*	0-3	22302	Sultan fsl	0-3	22302	Sumas sil, shallow	0-3	22302
Sultan sil	0-3	"	Sumas sil	0-3	"	Sumas sicl	0-3	"
Sultan sil	3-8	"	Sumas sil, deep	0-3	"	Sumas fsl	0-3	"
Sultan cl	0-3	"						

Land Capability Unit IIws03 (IIw2) consists of deep, well and moderately well drained, moderately coarse, and medium textured soils on gently sloping river flood plains.

Management problems are wetness by overbank flow flooding and maintenance of soil productivity. The soils are well suited for growing row crops, vegetables, vegetable seeds, strawberries, small grains, hay, and pasture. High yields can be maintained under an intensive conservation management program. Productivity of the soils and soil structure can be maintained under continuous cropping with the use of complete commercial fertilizers, winter cover crops, and green manures. Also, they can be maintained by growing hay and pasture 3 to 4 years, followed by strawberries 3 to 4 years; or hay and pasture 5 to 10 years, followed by row crops 1 to 2 years, with winter cover crops between consecutive years of row crops. Any combination of the conservation measures outlined above is designed to protect the soil against deterioration and to provide average to high yields. Crops respond well to supplemental irrigation during periods of low precipitation that might otherwise interrupt their growth cycle. The water intake rates are moderate and water-holding capacities are high.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Belfast sil	0-3	22303	Newberg sil	0-3	22303	Puyallup sil	3-8	22303
Camas cl	0-3	"	Nooksack sil*	0-3	"	Puyallup vfsl	0-3	"
Dungeness l	0-3	"	Nooksack fsl	0-3	"	Puyallup fsl	0-3	"
Dungeness sil	0-3	"	Puyallup l	0-3	"	Sultan l	0-3	"
Dungeness fsl	0-3	"	Puyallup sil	0-3	"	Sultan sil	0-3	"
Edgewick sil	0-3	"						

Land Capability Unit IIws04 (IIw3) consists of deep, medium and moderately fine textured soils, with slowly and moderately slowly permeable, fine textured subsoils. The soils occur on gently sloping alluvial flood plains and low terraces.

Management problems are wetness and maintenance of soil productivity. Flood prevention and improved land drainage are essential for growing row crops, vegetables, forage, small grains, hay, and pasture. These soils are suited for continuous cropping with the use of complete commercial fertilizers, winter cover crops, and green manures; also, they are suited for growing hay and pasture 3 to 4 years, with strawberries 3 to 4 years; or hay and pasture 5 to 10 years, followed by row crops 1 to 2 years, with winter cover crops between successive years of row crops. High crop yields are produced under a high level of conservation management on areas provided with drainage required by specific crops, with protection against flooding and sediment damages. Crops respond well to careful supplemental irrigation during periods of low precipitation. Overirrigation may aggravate the drainage problem and cause reduction of crop yields, particularly for those crops which require good drainage to depths of 20 inches or more.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Chehalis l	0-3	22304	Maytown l	0-3	22304	Samish sil	0-3	22304
Chehalis sil, mottled	0-3	"	Nookachamps sicl	0-3	"	Shuwah sicl	0-3	"
Chehalis sicl, "	0-3	"	Nookachamps sil	0-3	"	Skokomish sil	0-3	"
Cokedale sil/Puyallup	0-3	"	Puget sicl*	0-3	"	Snohomish sicl	0-3	"
Cokedale sil	0-3	"	Puget cl	0-3	"	Snohomish l	0-3	"
Cokedale l	0-3	"	Puget l	0-3	"	Snohomish sil	0-3	"
Lummi sil	0-3	"	Puget sil	0-3	"	Snohomish fsl	0-3	"
Lummi fsl	0-3	"	Puget fsl	0-3	"	Snohomish lfs	0-3	"
Maytown sil	0-3	"	Puget vfsl	0-3	"	Snohomish sic	0-3	"
Maytown sicl	0-3	"	Samish sicl	0-3	"			

Land Capability Unit IIws06 (IIw4) consists of deep, very poorly drained organic soils formed from sedges, woody and other organic materials in closed basins of bottom lands and uplands.

Organic soils have continuing wetness and soil management problems. Where drained, the soils settle about 1 inch per year. Generally, drained and fertilized organic soils are highly productive and well suited for growing hay and pasture, row crops, vegetables, and forage crops. These organic soils are well suited for irrigation. Their water intake rates are moderate and their water-holding capacities are high.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Carbondale muck	0-3	22306	McMurray peat	0-3	22306	Semiahmoo muck*	0-3	22306
Mukilteo peat	0-3	"	Rifle peat	0-3	"			

Land Capability Unit IIws09 (IIw5) consists of medium and moderately coarse textured somewhat poorly drained soils with slowly permeable subsoils occurring on gently sloping terraces.

Management problems in the use of this group are primarily, wetness, and secondarily, soils. Improved land drainage provides an environment suited for growing grasses and legumes for hay and pasture, silage, small grains, vegetables, hops, and cane berries. These soils are suited for continuous cropping, with the use of winter cover crops and green manure. They are also suited for growing hay and pasture 5 to 10 years, followed by row crops 1 to 2 years, with winter cover crops between successive years of row crops; or hay and pasture 5 to 10 years followed by cane fruits with annual cover crops 7 to 10 years. Crop yields are moderate to high under a high level of management. The soils are well suited for sprinkler irrigation; and irrigation during the dry summer season materially increases crop yields.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Orting l*	0-3	22309	Orting sl	0-3	22309	Sultan sil, shallow/Buckley	0-3	22309

Land Capability Unit IIws12 (IIw6) consists of gently sloping upland terraces which have a problem of wetness due to ponding. They have silt loam surfaces and sandy loam subsoils overlying dense clay marine and glacial sediments.

Management problems in the use of this group are primarily, wetness, and secondarily, soils. Except in low wet areas, the soils are well suited for growing grass and legumes for hay and pasture and for growing alfalfa. They are fairly well suited for growing small grains and vegetable crops. The soils are well suited for continuous cropping, provided green manures are used during winter seasons. They are suited for growing hay and pasture 5 to 10 years, followed by row crops 1 to 2 years, with winter cover crops between successive years of row crops. Crop yields are moderate to moderately high under a high level of conservation management.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Coupeville l	0-3	22312	Coupeville sil*	0-3	22312			

Land Capability Unit IIs01 (IIs1) consists of moderately deep and medium textured soils on nearly level to gently sloping uplands. The soils have a high content of volcanic ash.

Maintenance of soil productivity is the primary conservation management problem on the soils of this unit. The soils are well suited for growing strawberries, cane berries, vegetables, row crops, bulbs, small grains, forage, alfalfa, grasses and legumes for hay and pasture, and wood crops. The soils are suited for continuous cropping when winter cover crops, green manures, all available barnyard manure, and complete commercial fertilizers, are used. Also, they are suited for growing hay and pasture 3 to 4 years with strawberries 3 to 4 years; or hay and pasture 5 to 10 years followed by row crops, vegetables, or bulbs 1 to 2 years, with winter cover crops between successive years of row crops; or hay and pasture 5 to 10 years followed by cane fruits with annual cover crops 7 to 10 years. Crop yields are moderate to high under an intensive conservation management program.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Cinebar sil	0-3	23001	Giles sil*	3-8	23001	Salal sil	0-3	23001
Giles sil	0-3	"						

Land Capability Unit IIsw02 (IIs2) consists of gently sloping, deep terrace soils, with medium and moderately coarse textured surfaces and moderately fine textured subsoils.

Conservation management problems on this group of soils are maintenance of productivity and slight internal wetness. The soils are suited for growing grass and legumes, small grains, potatoes, strawberries, cane berries and wood crops. They are suited for continuous cropping by using winter cover crops, green manures, all available barnyard manure, and complete commercial fertilizers. Also, they are suited for growing hay and pasture, grass and legumes, 3 to 4 years followed by strawberries 3 to 4 years; or hay and pasture 5 to 10 years followed by row crops, potatoes, or bulbs 1 to 3 years, with winter cover crops between successive years of row crops; or cane fruits with annual cover crops 7 to 10 years. Crop yields are moderate to high under an intensive conservation management program. Windthrow is a moderate hazard to woodlands on these soils because of the dense silty clay loam subsoils which prevent root penetration to depths sufficient to support the trees. Crops grown on these soils respond well to treatment of barnyard manure and complete commercial fertilizers mixed to meet the requirements for specified crops. Lime applications may be beneficial to establishment and maintenance of the legumes and legume-grass mixtures.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Agnew l*	0-3	23202	Agnew fsl	3-8	23202			

Land Capability Unit IIsw03 (IIs3) consists of moderately deep, well drained moderately coarse textured soils on gentle slopes.

The conservation management problems are maintenance of productivity and local internal wetness. The soils are well suited for growing strawberries, cane berries, vegetables, peas, row crops, bulbs, small grains, forage, grasses and legumes for hay and pasture, and wood crops. These soils are suited for continuous cropping when winter cover crops, green manures and all available barnyard manure and complete commercial fertilizers are used. Also, they are suited for growing hay and pasture 3 to 4 years with strawberries 3 to 4 years; or hay and pasture 5 to 10 years with row crops, vegetables, peas or bulbs 1 to 2 years; or cane fruits with annual cover crops 7 to 10 years. Crop yields are moderate under an intensive conservation management program. Generally, most of these soils are under cultivation and are not used for wood crops. If they should be used for wood crops their production would be only moderate. Other crops grown on these soils respond well to treatment of barnyard manure and complete commercial fertilizers mixed to meet the requirements for specified crops. Lime applications may be beneficial to the establishment and maintenance of legumes and legume-grass mixtures.

Land Capability Unit IIsw03 (IIs3) (Con.)

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Ebeys sl*	0-3	23203	Ebeys sl	3-8	23203			

Land Capability Unit IIIew01 (IIIe1) consists of deep and moderately deep, moderately well drained glacial terraces on undulating topography. Their surfaces are medium textured, their subsoils are medium to moderately fine textured, and their substrata are cemented very gravelly sandy loams or sands.

The conservation management problems are primarily erosion control and drainage of low, wet areas. The soils are well suited for growing row crops, vegetables, strawberries, small grains, forage, grasses, legumes and wood crops. Adequate protection against accelerated erosion, maintenance of soil structure and productivity may be accomplished by growing grass and legume cover for 4 to 5 years, followed by 1 to 4 years of row crops, with winter cover crops between successive years of row crops; hay and pasture 3 to 4 years with strawberries 3 to 4 years; or hay and pasture 5 to 10 years with row crops 1 to 2 years. Crops grown on these soils produce average to high yields. The crops respond well to use of available barnyard manure with complete commercial fertilizer mixed to meet specific crop needs. Lime and fertilizer requirements for establishment and maintenance of crops can be determined by soil tests. Crops grown on soils of this management unit respond well to irrigation. The soil water intake rates are moderate, and their water-holding capacities are low. These soils have a good site index rating for growing Douglas-fir. Windthrow is a moderate hazard on these moderately deep soils over cemented glacial till. Douglas-fir saplings have severe competition from deciduous trees and brush unless the site is intensively managed.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Alderwood l	0-8	31201	Cagey sl	0-8	31201	Coveland sil	0-8	31201
Alderwood sil	0-8	"	Cagey sil	0-8	"	Kitsap l	3-8	"
Cagey gfsl	3-8	"	Coveland l	3-8	"	Kitsap sil*	3-8	"
Cagey gl	0-8	"	Coveland gl	3-8	"	Nesika l	0-8	"
Cagey gsl	0-8	"	Coveland gsil	3-8	"	Roche l	0-8	"

Land Capability Unit IIIew03 (IIIe2) consists of moderately deep, moderately well drained glacial terrace soils on undulating and rolling topography. Their surfaces consist of loams, gravelly loams and sandy loams; their subsoils are gravelly loams and silty clay loams; and their substrata are dense or cemented gravelly loams, silts and clays.

The soils are well suited for growing grasses, legumes, small grains, potatoes and wood crops. Adequate protection against accelerated erosion, maintenance of soil structure and productivity may be accomplished by growing grass and legume crops 4 to 5 years, followed by 1 to 4 years of row crops, with winter cover crops between successive years of row crops; hay and pasture 3 to 4 years with strawberries 3 to 4 years; or hay and pasture 5 to 10 years with row crops 1 to 2 years. Crops grown on these soils produce average to high yields. Crops respond well to irrigation during periods of low precipitation.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Agnew sl	8-15	31203	Clallam gl	3-8	31203	Clallam l*	3-8	31203

Land Capability Unit IIIes02 (IIIe3) consists of moderately deep and deep, medium and moderately fine textured, well drained soils formed on gently sloping glacial upland terraces. The substratum is compact glacial till or sandstone.

Conservation management problems are primarily, erosion control, and secondarily, maintenance of soil productivity. The soils are well suited for growing row crops, vegetables, strawberries, small grains, forage, grasses, legumes, and wood crops. Adequate protection against accelerated erosion, maintenance of soil structure and productivity can be accomplished by growing grasses and legumes 5 to 10 years, followed by 1 to 4 years of row crops with winter cover crops between successive years of row crops; or grasses and legumes 3 to 4 years with strawberries 3 to 4 years. Crops grown on these soils produce average to high yields, and respond well to irrigation during seasons of low precipitation. Suitability of the soils for growing Douglas-fir is good to very good, with site indexes ranging from 130 to 170. Brush competition is moderate. Susceptibility to windthrow is slight on the deep soils and moderate on soils 20 to 30 inches deep. Generally, logging equipment limitations are only moderate.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Cathcart l*	3-8	31302	Cathcart gsil	3-8	31302	Sauk l	3-8	31302
Cathcart cl	3-8	"	Delphi gl	8-15	"	Saxon sil	3-8	"
Cathcart fsl	3-8	"	Giles l	3-8	"	Wickersham shaly sil	3-8	"

Land Capability Unit IIIwe16 (IIIw1) consists of somewhat poorly drained and medium textured soils with compact, fine textured subsoils and substrata.

Conservation management problems are primarily wetness, and secondarily, erosion. These soils, where drained, are well suited for growing grasses, legumes, small grains, forage, annual row crops, and strawberries. Adequate soil protection may be attained by growing grass and legumes 5 to 10 years with 1 or 2 years of oats; grass and legumes 4 or 5 years with not more than 3 to 4 years of forage (corn); or row crops and winter cover crops between successive years of row crops. Crop yields are moderate under a conservation management program. Crops respond well to applications of manures and complete commercial fertilizers mixed to meet the requirements of each crop. The fertilizer and lime requirements of these soils may best be determined by soil tests. Crops respond well to supplemental irrigation during periods of low precipitation. Excess water caused by overirrigation may cause crop damage by waterlogging of the root zone above the restrictive zone. Likewise, a waterlogged soil may cause seep spots to develop in low lying areas by water moving laterally over restrictive layers. The problem may be corrected by reducing water applications, but should the problem extend over a wide area, correction may be by water interception ditches and tile to provide extra drainage capacity to promptly dispose of the excess water. Soils of this management unit are very well suited for growing Douglas-fir. However, they have moderate to severe equipment limitations due to seasonal wetness when the soils may become quick. Windthrow may be a moderate to severe hazard where depths over dense glacial till are 24 to 36 inches.

Land Capability Unit IIIwe16 (IIIw1) (Con.)

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Whatcom sil*	0-8	32116	Bow gsil	0-8	32116			

Land Capability Unit IIIwe17 (IIIw2) consists of upland terrace soils that are moderately shallow to shallow (12 to 36 inches deep), and poorly to somewhat poorly drained. The soils have medium and moderately coarse textured surfaces, and moderately coarse to moderately fine textured subsoils which overlie dense glacial till.

The primary conservation management problem is wetness, and the secondary problem is stabilization against erosion. The soils are suited for growing grasses, legumes, small grains, strawberries, and cane berries. They may be adequately protected against erosion losses and deterioration by growing grass and legumes 4 to 10 years with 1 or 2 years of small grains; grass and legumes 3 to 4 years with strawberries 3 to 4 years; or grass and legumes 5 to 10 years with cane fruits, and winter cover crops 7 to 10 years. Under a high level of conservation management, yields on these soils are moderate to high. The soils are suitable for irrigation during periods of low precipitation. Without drainage, these soils are best suited for growing wetland grasses and legumes, with small grains used periodically as cleanup crops. The soils, with site index ratings ranging between 140 and 160, rate as good for Douglas-fir production. Equipment limitations are moderate to severe. The soils may become quick when they are wet; therefore, the use of logging equipment may be limited to periods when the soils are not saturated. Logging equipment moving over saturated soils destroys soil structure, which results in slower drainage and causes a soil-moisture-air environment better suited for brush species than for regeneration of Douglas-fir.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Enumclaw l	3-8	32117	Kapowsin gl	3-8	32117	Kapowsin gsl	3-8	32117
Kapowsin gcl*	3-8	"						

Land Capability Units IIIws01, 02 (IIIw3) consist of moderately deep, well drained and somewhat excessively drained bottom lands subject to periodic overbank flow flooding and sedimentation. Their surfaces consist of medium to moderate or moderately fine textures.

The primary conservation management problem is overbank flow flooding, and the secondary problem is maintenance of soil productivity. The soils are well suited for growing grasses, legumes, alfalfa, pole beans, sweet corn, strawberries, and cane berries. High yields can be maintained under an intensive conservation management program. Productivity and protection of these soils can be attained by continuous row cropping with winter cover crops between successive years of row crops; growing grass and legumes 4 to 10 years, followed by 1 to 4 years of row crops, with winter cover crops between successive years of row crops; growing grasses and legumes 5 to 10 years, with strawberries 3 to 4 years; or by growing grasses and legumes 5 to 10 years, with cane fruits and winter cover crops 7 to 10 years. Any combination of the above outlined conservation measures is designed to protect the soil against deterioration and to provide average to high yields. Irrigation during periods of low rainfall promotes continued crop growth and increases production. Crops respond well to the use of all available barnyard manure, and to the use of complete commercial fertilizers mixed to meet specific crop needs. The fertilizer requirements for crops on each soil depend upon past management.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Belfast fsl	0-3	32301	Edgewick fsl	0-3	32301	Kline l	0-3	32302
Belfast sl	0-3	"	Eld sil	0-3	"	Kline l	3-8	"
Belfast sil	0-3	"	Eld l	0-3	32302	Kline sil*	0-3	"
Camas gl	0-3	"	Eld gl	0-3	"	Newberg fsl	0-3	32301
Cokedale sl	0-3	"	Eld sicl	0-3	"	Newberg l	0-3	"
Cokedale sicl/Puyallup	0-3	"	Kline gl	0-3	"	Puyallup fsl*	0-3	"
Dungeness fsl, shallow	0-3	"	Kline gl	3-8	"	Puyallup sl	0-3	"
Edgewick vfsl	0-3	"						

Land Capability Unit IIIws03 (IIIw4) consists of nearly level, deep and moderately deep (20-40 inches), medium, moderately fine, and moderately coarse textured bottom land soils. Their surfaces consist of medium to moderately fine textures which are medium to strongly acid.

Conservation management problems are primarily, wetness due to flooding by streambank overflow, and secondarily, soil productivity maintenance. Flood prevention and improved land drainage make these soils fairly well suited for growing row crops, vegetables, peas, sweet corn, grasses, legumes, and small grains. The soils can be protected against deterioration and productivity can be maintained by continuous row cropping with winter cover crops between successive years of row crops; growing grasses and legumes 4 to 10 years followed by row crops 1 to 4 years, with winter cover crops between successive years of row crops; growing grasses and legumes 3 to 4 years with strawberries 3 to 4 years; or growing grasses and legumes 5 to 10 years with cane fruits and winter cover crops 7 to 10 years. Crop yields are moderately high under such a system of conservation management. Irrigation is well suited to these lands during periods of low precipitation.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Cokedale sicl	0-3	32303	Maytown fsl	0-3	32303	Puyallup sl/Buckley substrata material	0-3	32303
Lummi sicl*	0-3	"	Nuby sil	0-3	"			

Land Capability Unit IIIws04 (IIIw5) occurs on gently sloping to gently undulating topography with slope gradients ranging between 1 and 8 percent. The surface soils consist of medium and moderately coarse textures with a reaction which ranges from pH 5.6 to 6.5. The substrata consist of moderately coarse dense basal till.

Conservation management problems are primarily, wetness, and secondarily, soil productivity maintenance. The soils are suited for growing grasses, legumes, small grains, peas, and strawberries. The land may be protected against deterioration by growing grasses and legumes 4 to 10 years, followed by row crops 1 to 4 years, with winter cover crops between successive years of row crops; grasses and legumes 3 to 4 years with strawberries 3 to 4 years; or grasses and legumes, 4 to 10 years followed by small grains or forage crops 1 to 4 years, with winter cover crops between successive years of row crops. These soils are suitable for sprinkler irrigation during periods of low precipitation. Crops respond well to irrigation. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
San Juan gsl, moderately deep	3-8	32304	San Juan l, moderately deep	3-8	32304	Sequim cl	0-3	32304
						Sequim gl*	0-3	"

Land Capability Unit IIIws05 (IIIw6) consists of poorly drained, moderately shallow (20 to 30 inches), moderately fine textured bottom land soils on nearly level topography. The soils have medium to strongly acid silt loam, clay loam and silty clay loam surfaces, with silty clay loam, clay loam and clay subsoils overlying clay substrata.

The primary conservation management problem is wetness, and the secondary problem is maintenance of soil productivity. These soils are best suited for growing grasses, legumes, corn, peas and broccoli. Yields are moderate, and limited by wetness and shallow rooting depths. Soils of this land class can be adequately maintained by growing grasses and legumes 4 to 10 years, followed by small grains 1 or 2 years; grasses and legumes 5 to 10 years with row crops (corn, peas or broccoli) 1 to 2 years, including a winter cover crop between successive years of row crops. Crop yields are moderate under a high level conservation management program. Without drainage, the soils are best suited for growing wetland grasses and legumes. Sprinkler irrigation during dry summer periods materially increases crop production. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Alluvial soils, undifferentiated	0-3	32305	Wapato cl	0-3	32305	Wapato sil-Galvin sil complex	0-3	32305
			Wapato sil	0-3	"			
Issaquah sil	0-3	"	Wapato sicl	0-3	"	Woodinville sil	0-3	"
Sammamish sil*	0-3	"						

Land Capability Unit IIIws08 (IIIw7) consists of moderately shallow, poorly drained soils with iron cemented subsoils which occur on nearly level basin-like topography of glacial outwash terraces.

Conservation management problems are primarily, wetness, and secondarily, maintenance of soil productivity. Where drained, the soils are suited for growing grasses, legumes, small grains, silage, and strawberries. Conservation measures necessary to maintain soil structure and productivity consist of growing grasses and legumes 3 to 4 years, with strawberries 3 to 4 years; grasses and legumes 4 to 5 years, with silage and forage crops 1 to 2 years; annual green manure crops between successive years of silage crops; or grasses and legumes 5 to 10 years with small grains 1 year. Crop yields range from moderately low to moderately high under a conservation management program. Limestone, available barnyard manure, and complete commercial fertilizers are beneficial in establishing and maintaining crops on these soils. Crops respond well to supplemental irrigation during the dry summer season. Irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Custer fsl	0-3	32308	Edmonds-Tromp sil	0-3	32308	Tromp-Tisch fsl complex	0-3	32308
Custer sl	0-3	"	Giles-Tromp sil	0-3	"			
Custer sil	0-3	"	Hale sil	3-8	"	Tromp-Custer sil	0-3	"
Edmonds l	0-3	"	Hale-Norma sil	0-3	"	Tromp-Edmonds sil complex	0-3	"
Edmonds sil	0-3	"	Tromp sil	0-3	"			
Edmonds sl*	0-3	"	Tromp fsl	0-3	"	Tromp-Woodlyn sil	0-3	"
Edmonds fsl	0-3	"	Tromp sicl	0-3	"	Woodlyn sil	0-3	"

Land Capability Unit IIIws09 (IIIw8) consists of moderately deep (20 to 36 inches), poorly drained soils, which occur on basin-like topography with slopes of less than 5 percent.

The primary conservation management problem is wetness, and the secondary problem is maintenance of soil productivity. Where drained, the soils are suited for growing grasses and legumes for hay and pasture, and for the production of silage. Under a high level of conservation management, yields are moderate. Conservation measures required to maintain production consist of growing grasses and legumes for hay and pasture 5 to 10 years, with small grains or row crops to reestablish grasses and legume stands, 1 to 2 years. Where drained, and during periods of low precipitation, these soils are suited for sprinkler irrigation. Supplemental irrigation, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Galvin sil	0-3	32309	Norma-Hale sil	0-3	32309	Norma sil	3-8	32309
Galvin sicl	0-3	"	Norma l*	0-3	"	Norma sic	0-3	"
Norma-Cagey sil	0-3	"	Norma l	3-8	"	Norma sicl	0-3	"
Norma cl	0-3	"	Norma sl	0-3	"	Orting gsl	0-3	"
Norma fsl	0-3	"	Norma sil	0-3	"			

Land Capability Unit IIIws10 (IIIw9) consists of moderately shallow soils 20 to 40 inches deep, which occur on nearly level basin topography with slope gradients of less than 3 percent.

Management problems are wetness and maintenance of soil productivity. The soils are best suited for growing grasses and legumes for hay and pasture, or for the production of forage in the form of silage. Conservation measures for maintaining the land consist of growing hay and pasture 5 to 10 years with 1 or 2 years of small grains, or hay and pasture (grasses and/or legumes) 5 to 10 years, with not more than 3 or 4 years of peas or corn, including cover crops between successive years of row crops. Without drainage, soils of this management group are suited for growing wetland grasses and legumes. The soils are suitable for sprinkler irrigation during periods of low precipitation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Bellingham cl	0-3	32310	Buckley-Enumclaw l	0-3	32310	Labounty-McKenna sicl complex	0-3	32310
Bellingham fsl	0-3	"	Clackamas sicl	0-3	"	McKenna sicl	0-3	"
Bellingham l	0-3	"	Clipper sicl	0-3	"	Rifle (McMurray) peat-Bellingham sicl (called complex peat)	0-3	"
Bellingham sil	0-3	"	Coveland l	0-3	"	Tisch sil	0-3	"
Bellingham sil	3-8	"	Coveland gl	0-3	"	Tisch sicl	0-3	"
Bellingham sicl*	0-3	"	Coveland gsil	0-3	"			
Bellingham sicl	3-8	"	Coveland sil	0-3	"			
Buckley l	0-3	"	Everson sil	0-3	"			
Buckley sil	0-3	"	Everson fsl	0-3	"			

Land Capability Unit IIIws11 (IIIw10) consists of poorly and imperfectly drained soils 20 to 30 inches deep, underlain by dense glacial clay basal till. The soils occur on nearly level topography with slope gradients of less than 3 percent.

Management problems are wetness and maintenance of soil productivity. These soils are best suited for growing grasses and legumes for hay and pasture, or for the production of forage in the form of silage. Adequate conservation measures for protection against deterioration may be attained by growing hay and pasture for 5 years, with 1 or 2 years of oats; or hay and pasture 4 to 5 years, with not more than 3 to 4 years of peas or corn, including winter cover crops between successive years of row crops. Without drainage, these soils are suited for growing wetland grasses and legumes. The soils are suitable for sprinkler irrigation during periods of low precipitation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Bow gsil, low rainfall phase	0-3	32311	Casey sil	0-3	32311	Hemmi sil*	0-3	32311

Land Capability Unit IIIws12 (IIIw11) consists of upland terrace soils which generally are moderately shallow (20 to 30 inches deep), and poorly to somewhat poorly drained. The soils occur on gently sloping topography with slope gradients of less than 3 percent. They have medium, moderately fine and moderately coarse textured surfaces, and moderately coarse to moderately fine textured subsoils which overlie dense glacial till or clay substrata.

Management problems are wetness and maintenance of soil productivity. The soils are suited for growing grasses and legumes for hay and pasture, silage, and strawberries. Adequate protection against deterioration from erosion and fertility depletion can be attained by growing grasses and legumes 4 to 10 years, with small grains 1 to 2 years; or grasses and legumes 5 to 10 years, with row crops (peas or corn) not more than 3 to 4 years, and winter cover crops between successive years of row crops. Without drainage, these soils are best suited for growing wetland grasses and legumes. The soils are suitable for sprinkler irrigation during seasons of low precipitation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	& Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Cagey gfsl	0-3	32312	Enumclaw fsl	0-3	32312	Labounty sil	0-3	32312
Cagey gsl	0-3	"	Enumclaw gsl	0-3	"	Nesika l	0-3	"
Cagey sil-Norma sicl complex	0-3	"	Kapowsin gl	0-3	"	Puyallup-Buckley fsl	0-3	"
Enumclaw l	0-3	"	Kitsap sil*	0-3	"	Waddell sicl	0-3	"

Land Capability Unit IIIs01 (IIIs1) consists of glacial terraces and alluvial fans with nearly level to undulating topography (0-8 percent slopes). The soils have loam and silt loam surfaces, and loam, sandy loam or loamy sand subsoils overlying sands, gravelly sands or shale substrata.

The primary management problem is maintenance of soil productivity. The soils are suited for growing grasses, legumes, small grains, corn, potatoes, strawberries, and cane fruits. Adequate protection against soil deterioration can be attained by growing grasses and legumes 5 to 10 years with 1 or 2 years of small grains; grasses and legumes 4 to 5 years with not more than 3 to 4 years of row crops, potatoes or corn, and winter cover crops between successive years of row crops; grasses and legumes 3 to 4 years, followed by strawberries 3 to 4 years; or grasses and legumes 5 to 10 years followed by cane fruits, with winter cover crops 7 to 10 years. Crop yields are moderate under a conservation management program. Crops respond well to applications of manure and complete commercial fertilizers mixed to meet the requirements of each crop. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Gilligan l	0-3	33001	Indianola l	3-8	33001	Wickersham shaly l	0-3	33001
Gilligan gl	0-3	"	Kickerville sil	3-8	"	Wickersham shaly l	3-8	"
Gilligan sil	0-3	"	Lynden l*	0-3	"	Wickersham shaly sil	0-3	"
Gilligan sil, shallow	0-3	"	Lynden l	3-8	"			

Land Capability Unit IIIs06 (IIIs2) occurs on glacial outwash terraces with nearly level topography in a climatic zone having 15 to 20 inches of annual precipitation. It has a loamy fine sand surface, and a slightly acid (pH 6.1-6.5) loamy fine sand subsoil over a loose, loamy sand substratum.

The primary problem is soil management. The soil is suited for growing grasses, legumes, alfalfa, small grains, peas, potatoes, forage crops, strawberries, and cane fruits. The soil structure and soil productivity can be maintained by growing one or a combination of the following crops: grasses and legumes for 4 to 10 years followed by row crops 1 to 4 years, with winter cover crops between successive years of row crops; grasses and legumes 5 to 10 years, with 1 or 2 years of small grain; grasses and legumes 3 to 4 years, with strawberries 3 to 4 years; or grasses and legumes 5 to 10 years, with cane fruits and winter cover crops 7 to 10 years. Crop yields are moderate under a conservation management program. This soil responds well to sprinkler irrigation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code
Dick lfs	3-8	33006

Land Capability Unit IIIs08 (IIIs3) consists of deep, and well to moderately well drained soils with surfaces and subsoils of medium to strongly acid loams and silt loams. Their substrata consist of medium acid silt loams, silty clay loams, and fine sandy loams.

Management problems are maintenance of soil productivity, and wetness. The soils are well suited for growing strawberries, cane berries, vegetables, row crops, bulbs, small grains, forage, alfalfa, grasses and legumes for hay and pasture, and wood crops. They are suited for continuous cropping when winter cover crops, green manures, all available barnyard manure, and complete commercial fertilizers are used. Also, they are suited for growing hay and pasture 3 to 4 years; strawberries 3 to 4 years; hay and pasture 5 to 10 years, with row crops, vegetables, or bulbs 1 to 2 years; or cane fruits with annual cover crops 7 to 10 years. Crop yields are moderate to high under an intensive conservation management program. The wood crop productive potential is moderate to high. Lime applications may be beneficial to establishment and maintenance of legumes and legume-grass mixtures. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Giles l*	0-3	33008	Giles fsl	0-3	33008	Sauk l	0-3	33008
Giles sil (g subsoil)	3-8	"	Salal fsl	0-3	"	Winston gsl	0-3	"

Land Capability Unit IIIsw09 (IIIs4) consists of moderately well drained, moderately deep glacial terraces on nearly level to undulating topography, with 0 to 8 percent slopes. The soils consist of loam, gravelly loam, and gravelly sandy loam, and the subsoils consist of moderately to strongly acid gravelly sandy loam, silty clay loam, or silty clay. The substrata are gravelly sandy loam, silty clay, sandy clay, or sandy clay loam cemented glacial till.

Management problems are maintenance of soil productivity, and wetness. Wetness is caused by flooding due to ponding during periods of excess precipitation. The soils are well suited for growing grasses, legumes, small grains, strawberries, cane fruits, and wood crops. Crop yields under a conservation management program are moderate to high. The land can be maintained against deterioration of soil and production can be maintained by growing grasses and legumes 4 to 10 years followed by 1 to 4 years of row crops, with winter cover crops between successive years of row crops; grasses and legumes 3 to 4 years, with strawberries 3 to 4 years; grasses and legumes 5 to 10 years, with cane fruits and winter cover crops 7 to 10 years; or, grasses and legumes 4 to 10 years, followed by 1 to 2 years of small grains. Sprinkler irrigation is well suited to these soils, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Alderwood gl	0-3	33209	Roche gl*	0-3	33209	Waddell l	3-8	33209
Cloquallum l	3-8	"	Roche gl	3-8	"	Waddell gl	3-8	"
Roche l	0-3	"	Roche gsl	3-8	"	Waddell gl	8-15	"

Land Capability Unit IVew03 (IVe1) consists of moderately deep (20-36 inches), moderately well drained, moderately coarse, medium and moderately fine textured soils on glacial terraces, in a climatic zone having 20 to 30 inches of precipitation annually.

The primary problem is erosion control, and the secondary problem is flooding by ponding. Generally, the ponding appears as seeped areas on slopes or in small depressions. The soils are well suited for growing grasses, legumes, small grains, alfalfa, cane fruits and grapes. The land can be protected against deterioration from erosion, and fertility and productivity can be maintained, by growing grasses and legumes 4 to 10 years, with 1 or 2 years of small grains; or grasses and legumes 5 to 10 years followed by cane fruits or grapes 7 to 10 years, with winter cover crops between rows. Crop yields are moderate under a conservation management program. The soils are well suited to sprinkler irrigation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential. The rotations indicated above are adequate to prevent sediment sources, to protect soils against erosion losses, and to protect water quality in the streams.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Clallam gsl	3-8	41203	Sinclair gfsl	8-15	41203	Swantown l	8-15	41203
Elwha l	8-15	"	Sinclair shotty l*	8-15	"	Whidbey gsl	8-15	"
Sinclair gl	8-15	"	Sinclair shotty cl	3-8	"			

Land Capability Unit IVew12 (IVe2) consists of soils with loam, silt loam and silty clay loam surfaces, and silty clay loam subsoils, and their substrata consist of cobbly and gravelly clay, and silty clay dense basal till. The soils occur on rolling topography with slope gradients of 3 to 15 percent.

The primary management problem is control of erosion and sediment, and the secondary problem is wetness. These soils are well suited for growing grasses, legumes, small grains, and wood crops. Protection against soil deterioration can be accomplished by crop rotations which consist of growing grasses and legumes for hay and pasture 5 to 10 years, with oats or other small grains one year as a cleanup crop prior to reestablishing desired grasses and legumes. Yields are moderate to high under a conservation management program. Crops respond well to applications of manures and complete commercial fertilizers. Sprinkler irrigation is fairly well suited to these soils. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential. The above rotation will prevent sources of sediment, and will help to maintain the desired water quality of the streams.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Bow cl	8-15	41212	Bow sicl	8-15	41212	McKenna l	8-15	41212
Bow gl	3-8	"	Bow sil	3-8	"	Stossel cl	8-15	"
Bow gl	8-15	"	Bow sil	8-15	"	Whatcom sil*	8-15	"
Bow l	8-15	"	Casey fsl	8-15	"	Whatcom sil-McKenna sil complex	3-8	"
Bow sicl	3-8	"	Casey l	8-15	"			

Land Capability Unit IVew14 (IVe3) consists of moderately deep and imperfectly drained soils on old glacial terraces with rolling topography. Their slope gradients range between 3 and 15 percent. The surface soils are silt loams and silty clay loams, the subsoils are loams and silty clay loams, and the substrata are cemented basal till consisting of gravelly sandy loam, gravelly clay loam or gravelly clay.

Stabilization of soils against erosion is the primary management problem, and wetness is secondary. The soil erosion and sediment hazards can be reduced and soil tilth, moisture-holding capacity, and crop yields can be improved by growing grasses and legumes for hay and pasture 5 to 10 years, with small grains 1 year as a cleanup crop, prior to reestablishing desired grasses and legumes. Crop yields are moderate under a good conservation management program. Crops respond well to applications of available manures and complete commercial fertilizers. Sprinkler irrigation is fairly suitable for these soils, considering their moderate water intake rates and water-holding capacities in the usable soil profile. Crops respond well to irrigation during periods of moisture deficiencies, and where fertilizers are used, crop yields may approach their potential. Crop rotations indicated above are adequate to control erosion and to reduce stream sediments and pollution.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Cloquallum sil	8-15	41214	Kitsap sil	8-15	41214	Squalicum gsil	8-15	41214
Cloquallum sil, shallow	8-15	"	Kitsap sicl*	8-15	"	Squalicum sil	8-15	"
			Labounty sil	8-15	"	Squalicum stsil	8-15	"
Cloquallum sicl	8-15	"	Quilcene sicl	8-15	"	Wilkeson l	8-15	"
Kitsap gl	8-15	"	Squalicum-Alderwood sil	8-15	"	Wilkeson sil	8-15	"
Kitsap sil-Indianola sl complex	8-15	"				Prather sicl	8-15	"
			Squalicum gsil	3-8	"			

Land Capability Unit IVew22 (IVe4) consists of moderately deep and deep, moderately well and imperfectly drained, glacial terrace soils, overlying cemented glacial basal till. The soils occur on slopes ranging between 3 and 15 percent. Their surfaces consist of medium and coarse textures which are silt loam, loam, gravelly loam, fine sandy loam and gravelly sandy loam. Their subsoils consist of coarse, moderately coarse, and moderately fine textures which are gravelly sand, gravelly sandy loam, sand, and gravelly clay loam.

Stabilization of soils against erosion is the primary problem, and wetness is the secondary problem. The soils are well suited for growing grasses, legumes, small grains, and wood crops. The soil erosion and sediment hazard can be reduced, and soil tilth, moisture-holding capacity, and crop yields can be improved by growing grasses and legumes for hay and pasture 5 to 10 years, with small grains for 1 year as a cleanup crop, prior to reestablishing desired grasses and legumes. Crop yields are moderate under a good conservation management program. Crops respond well to applications of available manures and complete commercial fertilizers. Sprinkler irrigation is fairly well suited for soils of this group during periods of moisture deficiencies. Crops respond well to supplemental irrigation, and with fertilizers, yields may approach their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Alderwood fsl	3-8	41222	Alderwood gsl shallow	3-8	41222	Roche gl	8-15	41222
Alderwood fsl	8-15	"	Alderwood gsl shallow	8-15	"	Roche l	8-15	"
Alderwood gl	3-8	"	Bozarth fsl	8-15	"	Roche stl	8-15	"
Alderwood gl	8-15	"	Cagey gsl	8-15	"	Tenino gsl	8-15	"
Alderwood gsl*	3-8	"	Cagey sil	8-15	"			
Alderwood gsl	8-15	"	Kapowsin gl	8-15	"			

Land Capability Unit IVes06 (IVe5) consists of moderately deep and deep, somewhat excessively drained, medium and coarse textured glacial outwash soils on slopes which range between 3 and 15 percent. The soils have silt loam, gravelly silt loam, and gravelly sandy loam surfaces. Their subsoils consist of gravelly sands and gravelly loams overlying gravelly sand substrata.

Stabilization of soils against erosion, and maintenance of soil structure, are the primary problems. The soils are well suited for growing grasses, legumes, small grains, and wood crops. They are best suited for growing grasses and legumes for hay and pasture 5 to 10 years, with small grains for 1 year as a cleanup crop prior to reestablishing the desired grasses and legumes. Crop yields are moderate to moderately low under a conservation management program. However, the crops respond well to applications of available manures and complete commercial fertilizers.

Land Capability Unit IVes06 (IVe5) (Con.)

Sprinkler irrigation is well suited to these soils, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Barneston sil	8-15	41306	Barnhardt gsil	8-15	41306	Corkindale l	8-15	41306
Barnhardt gsl	8-15	"	Corkindale l	3-8	"	Kickerville sil*	8-15	"

Land Capability Unit IVes07 (IVe6) consists of moderately deep, well drained, gravelly, moderately coarse textured soils on low terraces with slopes which range between 3 and 15 percent. Their surfaces consist of loams and gravelly loams. Their subsoils are strongly acid, firm, gravelly, and very gravelly loams, which overlie very gravelly, cobbly and bouldery loams and sands.

Stabilization of soils against erosion and maintenance of soil structure are the primary management problems. The soils are well suited for growing grasses, legumes, small grains, and wood crops. They are well suited for growing grasses and legumes for hay and pasture 5 to 10 years, with small grains for 1 year as a cleanup crop, prior to reestablishing grasses and legumes. Crop yields are moderate to moderately low under a conservation management program. The soils are fairly well suited for sprinkler irrigation during periods of moisture deficiencies, and supplemental irrigation, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Nesika l soils, undifferentiated	3-8	41307	Sol Duc gl*	8-15	41307			

Land Capability Unit IVes08 (IVe7) consists of moderately deep and shallow, moderately well drained, moderately coarse, and medium textured glacial terrace soils overlying dense, cemented glacial till. Slopes range between 3 and 15 percent. Their surfaces consist of gravelly sandy loam and gravelly loam which have an acidity ranging between pH 5.1 and 6.0. Their subsoils consist of gravelly sandy loam and gravelly loam overlying dense cemented gravelly sandy loam glacial basal till.

Management problems are the control of erosion and sedimentation, and maintenance of soil structure and productivity. While most of these soils are used for the production of wood crops, and watershed protection for reservoirs, they are suited for growing grasses, legumes, small grains, and wood crops. Where used for agriculture, the soils can be protected against erosion and deterioration by growing grasses and legumes for 5 to 10 years, with small grains for 1 year, prior to reestablishing the desired grasses and legumes. Shallow soils with limited water-holding capacities cause severe limitations for sprinkler irrigation.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Skiyou gl*	3-8	41308	Skiyou gl	8-15	41308	Tokul gsl	8-15	41308

Land Capability Unit IVes09 (IVe8) consists of moderately deep, moderately fine textured soils overlying cemented glacial till and compact sands or bedrock at 40 to 48 inches. They occur on old upland terraces, with slopes ranging between 8 and 15 percent. Their surfaces consist of medium to strongly acid loam, gravelly loam, silt loam, and fine sandy loam. Their subsoils consist of loam, silty clay loam, and gravelly sandy loam over compact to strongly cemented sandy loam, gravelly sandy loam, or fine sandy loam.

Management problems are erosion and sedimentation hazards, and maintenance of soil structure and productivity. The soils are well suited for growing grasses, legumes, small grains, and wood crops. Conservation measures necessary to protect the soil against erosion and sediment hazards include growing grasses and legumes for hay and pasture 5 to 10 years, with oats used as a cleanup crop prior to reestablishing desired grasses and legumes. The soils are well suited for sprinkler irrigation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Cathcart gl	3-8	41309	Giles l	8-15	41309	Saxon sil	8-15	41309
Cathcart gl	8-15	"	Giles sil	8-15	"	Shelton gl	8-15	"
Cathcart l	8-15	"	Nordby l	3-8	"	Shelton gsl*	8-15	"
Giles fsl	8-15	"	Nordby l	8-15	"			

Land Capability Units IVes10, 11 (IVe9) consist of moderately shallow, moderately well and well drained, medium and moderately coarse textured glacial terrace soils on 3 to 15 percent slopes, in a climatic zone having 18 to 22 inches of precipitation annually. Their surfaces are sandy loam or gravelly sandy loam. Their subsoils consist of gravelly loam, gravelly sandy loam, or sandy loam, overlying cemented basal till of gravelly clay loam and gravelly sandy loam.

Management problems include the control of erosion and reduction of sediment, and maintenance of soil structure and productivity. These soils are suited for growing grasses, legumes, small grains, and wood crops. The conservation measures required to prevent soil erosion and soil deterioration include growing grasses and legumes 5 to 10 years, with small grains 1 to 2 years to establish seedings. Woodland use adequately protects the land against accelerated soil erosion, except for areas which have been recently logged. The soils are well suited for irrigation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
San Juan, gsl, moderately deep	8-15	41311	Townsend fsl	3-8	41310	Townsend sl*	8-15	41310

Land Capability Units IVes13, 16 (IVe10) consist of moderately deep, well, and moderately well drained soils overlying basalt, sandstone or schist bedrock at 24 to 60 inches. Their slopes range between 8 and 15 percent. Their surface textures consist of loam and silty clay loam, and their subsoils consist of loam, shaly loam, clay loam and silty clay loam overlying bedrock.

Management problems are erosion and sediment control, and maintenance of soil structure and productivity. The soils are suited for growing grasses, legumes, small grains, and wood crops. Adequate protection against accelerated soil erosion and sediment hazards, and maintenance of soil structure, may be accomplished by growing grasses and legumes 5 to 10 years, followed by small grains 1 year, to reestablish the cover. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, increases crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Heisler shaly l*	8-15	41313	Melbourne sicl*	8-15	41316	Schnorbush l	8-15	41313
Melbourne l	8-15	41316	Olympic sicl	8-15	"	Tebo l	8-15	41316

Land Capability Units IVws01, 02, 03 (IVw1) consist of deep, coarse, and moderately coarse textured alluvial soils. Their surfaces are loamy sandy and sandy loams which overlie sands and gravelly sands. The flood hazard is severe.

Management problems are wetness, and maintenance of soil productivity. This conservation management group of soils is best suited for growing grasses and legumes for hay and pasture, or trees for wood crops. Conservation measures suited for protecting these soils consist of growing grasses and legumes 5 to 10 years, with peas or silage corn 1 to 2 years to reestablish grass and legume cover. The soils are well suited for growing cottonwood for wood crops. They have low water-holding capacities and require frequent irrigation; however, during periods of moisture deficiencies, irrigation increases crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Kline sl	0-3	42302	Pilchuck fsl*	0-3	42301	Sultan ls	0-3	42303
Newberg sl	0-3	"	Puyallup lfs	0-3	42302			

Land Capability Unit IVws05 (IVw2) consists of deep, poorly drained soils with clay or silty clay surfaces and clay subsoils and substrata. These circumstances contribute to continuing wetness following floodwater recession.

Management problems are wetness, and maintenance of soil productivity. The soils are best suited for growing grasses and legumes for pasture, and cane berries. Conservation measures required to maintain these soils in a moderate to high state of productivity include growing hay and pasture 5 to 10 years, followed by cane berries 7 to 10 years. The soils have severe limitations for irrigation; however, supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Puget c*	0-3	42305	Puget sic	0-3	42305	Puyallup-Puget ls	0-3	42305

Land Capability Unit IVws06 (IVw3) consists of shallow (12 to 20 inches deep), very poorly drained organic soils made up of peats and mucks overlying silts, sands, clays, and gravelly materials. Their quality after shrinkage to the mineral soil material depends upon the nature of the underlying subsoil. These organic soils will settle or shrink at the rate of about one inch per year.

Management problems are wetness, and maintenance of soil productivity. The soils are best suited for growing grasses and legumes for hay and pasture. However, until such time as soil settling has reduced the thickness of the organic layer to about 12 inches, the soils are suited for growing vegetables and blueberries.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Carbondale muck, shallow	0-3	42306	Rifle peat, shallow	0-3	42306	Spalding peat, burned phase	0-3	42306
Carbondale muck	3-8	"	Rifle peat-Bellingham sicl complex	3-8	"	Tacoma peat	0-3	"
Dupont muck	0-3	"	Semiahmoo muck, shallow*	0-3	"	Tacoma muck, shallow	0-3	"
McMurray muck	0-3	"				Tanwax peat	0-3	"
McMurray peat, shallow	0-3	"	Semiahmoo-Tanwax muck/peat	0-3	"	Tanwax peat, shallow	0-3	"
Mukilteo peat	8-15							
Mukilteo peat, shallow	0-3							

Land Capability Units IVws07, 08 (IVw4) consist of moderately shallow, poorly drained basin soils, with iron cemented subsoils and cemented or dense clay substrata. The soils occur on upland and terrace basins with slopes of less than 3 percent. Their surfaces consist of loams, gravelly loams, silt loams, gravelly sandy loams and loamy sands. Their subsoils consist of iron cemented sands overlying cemented sand or glacial clay till. They are subject to flooding due to ponding during periods of excess precipitation.

Management problems are wetness, and maintenance of soil fertility. Where drained, the soils are suited for growing grasses, legumes, and small grains. Where undrained, they are suited for growing Reed canarygrass and similar wetland grasses. The soil structure and productivity can be maintained by growing grasses and legumes 5 to 10 years, with 1 year of small grains to reestablish the grass and legumes. The soils are only fairly well suited for supplemental irrigation during periods of moisture deficiencies. Irrigation, along with the use of fertilizers, may increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Edmonds ls	0-3	42308	Koch gsl	0-3	42308	Schooley l	0-3	42307
Koch gl	0-3	"	Koch sil*	0-3	"			

Land Capability Units IVws09, 10 (IVw5) consist of poorly drained, moderately fine, and fine textured terrace and upland basin soils overlying restrictive layers at depths of 20 to 30 inches. The soils are subject to flooding by ponding during periods of excess precipitation.

Management problems are wetness, and maintenance of soil structure and productivity. The soils are suited for growing grasses, legumes, and small grains. They are fairly well suited to sprinkler irrigation, and supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Bellingham c	0-3	42310	Everson cl	0-3	42309	Reed c	0-3	42310
Bellingham sic*	0-3	"	McKenna gl*	0-3	"	Reed sicl	0-3	"
Bellingham sicl	0-3	"	McKenna gcl	0-3	"	Skagit sicl	0-3	"
Buckley cl	0-3	"	McKenna l	0-3	"	Thornton c	0-3	"
Buckley l	0-3	"	Orting stsl	0-3	"	Thornton sicl	0-3	"

Land Capability Unit IVws11 (IVw6) consists of moderately shallow to shallow, poorly drained and imperfectly drained, medium, moderately fine, and fine textured upland terrace soils, on slopes of less than 8 percent. Their surfaces consist of loam, gravelly loam, silt loam, silty clay loam, and fine sandy loam, with an acidity of pH 5.1 to 6.0. Their subsoils consist of dense plastic clay, silty clay loam, or loam, and their substrata are dense plastic clay, silty clay, or silty clay loam. These soils are subject to flooding by ponding.

Management problems are wetness, and maintenance of soil structure and productivity. The soils are best suited for growing grasses, legumes, small grains, and wood crops. Conservation measures necessary to maintain these soils include grass and legume cover for 5 to 10 years, with small grains for 1 year to reestablish a grass and legume cover. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Bow l	0-3	42311	Bow gl*	0-3	42311	Casey l	0-3	42311
Bow l	3-8	"	Bow sil	0-3	"	Klaber sicl	0-3	"
Bow l, shallow	0-3	"	Bow sil, shallow	0-3	"	Kopiah l	0-3	"
Bow l-Bellingham sicl complex	3-8	"	Bow sil, shallow	3-8	"	Kopiah sicl	0-3	"
			Casey fsl	0-3	"	Kopiah sil	0-3	"

Land Capability Units IVws12, 13 (IVw7) consist of moderately deep, moderately well drained, moderately fine textured soils overlying cemented glacial lacustrine substrata material. Their surfaces consist of silt loams and silty clay loams which have an acidity of pH 5.6 to 7.3. Their subsoils consist of plastic clay loams and silty clay loams which overlie sticky and plastic, densely cemented, silty clay loam and clay loam.

Management problems are wetness, and maintenance of soil structure and productivity. The soils can be stabilized and their productivity and soil structure maintained by following a rotation of growing hay and pasture 5 to 10 years, with small grains 1 year as a cleanup crop prior to reestablishing desired grasses and legumes. Crops grown upon these soils respond well to applications of barnyard manure and commercial fertilizers. Supplemental irrigation during periods of deficient moisture, where fertilizers are used, will usually increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Agnew-Elwha sicl	0-3	42313	Cloquallum sil	3-8	42312	Kitsap sicl	0-3	42312
Agnew sicl*	3-8	"						

Land Capability Unit IVws43 (IVw8) consists of moderately deep, moderately well drained, moderately coarse textured soils on cemented glacial till terraces, with slopes which are generally less than 3 percent. Their surfaces consist of silt loam, loam, gravelly loam, gravelly sandy loam and fine sandy loam with an acidity of pH 5.1 to 6.0. Their subsoils consist of gravelly sandy loam overlying gravelly sandy loam cemented glacial till substrata. The soils are subject to seasonal water tables in their profiles, and ponding of low areas, during periods of excess precipitation.

Management problems are wetness, and maintenance of soil structure and productivity. Conservation measures required are crop rotation and land drainage. Land drainage can be accomplished by light land smoothing and tile drains to low wet areas. The soils are suited for growing grasses and legumes with rooting depths of less than 20 to 30 inches. They can be adequately protected against deterioration of productivity and structure by following a rotation of growing grasses and legumes 5 to 10 years, followed by 1 year of small grains to reestablish desired grasses and legumes. Crops respond well to irrigation during periods of deficient moisture, and, with applications of manure and complete commercial fertilizers, crop yields may approach their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Alderwood gsl, shallow	0-3	42343	Bozarth fsl*	0-3	42343	Swantown l	0-3	42343
			Swantown gl	3-8	"	Whidbey gsl	0-3	"

Land Capability Units IVs01, 10, 12 (IVs1) consist of somewhat excessively drained, moderately deep and deep, coarse and moderately coarse textured glacial outwash soils, on slopes of less than 15 percent gradient. Their surfaces consist of silt loam, loam, and fine sandy loam; some are gravelly. Their acidity ranges between pH 5.1 and 6.5. Their subsoils consist of gravelly sands and loamy sands.

Land Capability Units IVs01, 10, 12 (IVs1) (Con.)

The primary management problem is maintenance of soil structure and productivity. The soils are suited for growing grasses, legumes, small grains, potatoes, strawberries, cane fruits, and wood crops. Conservation measures required to maintain soil structure and productivity consist of growing grasses and legumes for hay and pasture 5 to 10 years, with 1 year of small grains as a cleanup crop prior to reestablishing desired grasses and legumes; grasses and legumes for hay and pasture 5 to 10 years, with oats for 1 year as a cleanup crop, and strawberries 3 to 4 years; grasses and legumes 5 to 10 years, with cane fruits 7 to 10 years and annual cover crops between rows of cane fruits; or grasses and legumes 5 to 10 years, small grains 1 year as a cleanup crop, and potatoes or vegetables 1 to 2 years. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Barneston gfsl	0-3	43001	Indianola fsl	3-8	43001	Snakelum cosl	0-3	43010
Barneston gfsl	8-15	"	Indianola sl	0-3	"	Snoqualmie gl	3-8	43001
Barneston gsl	8-15	"	Indianola sl	3-8	"	Sol Duc gl	0-3	"
Barneston sil	3-8	"	Indianola sil	3-8	"	Sol Duc gsl	0-3	"
Barnhardt gsl	3-8	"	Lynden gl	0-3	"	Spanaway gsl*	0-3	43010
Carlsborg gl	0-3	43010	Lynden gl	3-8	"	Spanaway gsl	3-8	"
Corkindale l	0-3	43001	Lynden gsl	3-8	"	Spanaway gsl	8-15	"
Crescent gl	3-8	"	Lynden sl*	3-8	"	Townsend l	3-8	"
Everett gl	0-3	"	National pumicy l	3-8	43012	Townsend gl	3-8	43110
Everett gl	3-8	"	National pumicy sl*	3-8	"	Townsend sl	0-3	43010
Everett gl	8-15	"	Neptune sl	0-3	43001	Tumwater fsl	0-3	"
Grove gl	0-3	"	Nisqually ls	3-8	43010	Tumwater lfs	0-3	"
Grove gl	8-15	"	Ragnar fsl	3-8	43012			
Grove gl, basin phase	0-3	"	Smith Creek gl	3-8	43001			

Land Capability Units IVse05, 11, 13 (IVs2) consist of somewhat excessively drained, ceep, coarse textured glacial outwash soils on slopes ranging between 8 and 15 percent gradient. Their surfaces consist of sandy loam, fine sandy loam, and loamy sand; some are gravelly. Their subsoils and substrata consist of loamy sand and sand. Their acidity ranges between pH 4.5 and 6.5.

Management problems are maintenance of soil productivity, and erosion and sediment control. The soils are suited for growing grasses, legumes, alfalfa, small grains, and wood crops. The conservation measures required to protect the soil against deterioration and erosion consist of growing grasses and legumes 5 to 10 years, with 1 year of small grains to reestablish the desired grasses and legumes. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Indianola fsl*	8-15	43105	Lynden gsl	8-15	43105	Ragnar fsl*	8-15	43113
Indianola lfs	8-15	"	Lynden sl	8-15	"	Snakelum cosl	8-15	43111
Indianola ls	8-15	"	Lystair fsl	8-15	"	Tumwater lfs	8-15	"
Indianola sl	8-15	"	Nisqually ls	8-15	43111			

Land Capability Units IVsw06, 09 (IVs3) consist of moderately deep, moderately well drained, moderately coarse, and moderately fine textured glacial terrace soils overlying cemented glacial till substrata. Slopes range between 0 and 8 percent. Their surfaces consist of gravelly sandy loams, stony loams and gravelly silt loams with an acidity which ranges between pH 5.1 and 6.0. Their subsoils consist of gravelly sandy loam, fine sandy loam, and silty clay loam overlying cemented substrata.

Management problems are maintenance of soil productivity, and wetness. The soils are suited for growing grasses, legumes, small grains, cane fruits, and wood crops. Conservation measures necessary to protect the soil and maintain its productivity consist of growing grasses and legumes 4 to 10 years, with 1 year of small grains; or grasses and legumes 4 to 10 years, with cane fruits 7 to 10 years. Supplemental irrigation during periods of moisture deficiencies, where fertilizers are used, may increase crop yields to near their potential.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Alderwood gsl*	0-3	43209	Shelton gsl	3-8	43209	Whidbey gsl*	3-8	43206
Alderwood gsl	3-8	"	Sinclair gsl	3-8	43206			
Roche stl	3-8	"	Squalicum gsil	0-3	43209			

Land Capability Units Vws21 and VIws02 (Vw1) consist of very poorly drained basin soils which occur behind ridges in coastal beach areas. These soils have a high water table that remains near the surface during most of the year. They lie within a few hundred feet of areas covered by tidal waves. As a result, the lower part of the profile is affected by salt water. The soil surface layers are dark in color, and overlie coarse textured sediments that extend to depths of many feet. The vegetation consists of sedges, reeds, and grasses that tolerate salt water. Most of the area is idle.

The primary management problem is the very wet condition of the soils which limits their use to growing vegetation that provides wildlife protection. The areas are best suited for the development of wildlife reserves. In some places, limited grazing is practiced during periods of below-normal precipitation. The soils are too wet and salty for other uses.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Alluvial complex	0-3	52321	Hovde l	0-3	62302	Hovde s	0-3	62302
Hovde gsl	0-3	"	Hovde ls	0-3	52321	Hovde sicl	0-3	52321

Land Capability Units VIes18, 19, 22 and VIs19 (VIe1) consist of deep, somewhat excessively drained, moderately coarse and coarse textured, glacial outwash terrace soils on rolling and hilly topography, with slope gradients between 8 and 30 percent. The surface water runoff is medium to rapid, and the erosion hazard is severe.

Management problems are erosion, and soil droughtiness. Where cleared, the soils are suited for growing grasses, legumes, and wood crops. The land should be cultivated only to the extent necessary to establish or reestablish grass and legume cover. Erosion and droughtiness make the soils better suited for permanent vegetation or pasture, wood crops, wildlife, and recreational uses than for rotation cropland.

Mapping Unit	% Slope	ADP Code
Barneston gfsl	15-30	61319
Barneston gls	15-30	"
Barneston gsl-Wilkeson sil complex	15-30	"
Barneston sil	15-30	"
Barneston stsil	8-15	"
Barnhardt gsil	15-30	"
Chimacum gl	15-30	61322
Chimacum gsl	15-30	"
Chimacum vgls	15-30	"
Corkindale l	15-30	61319
Everett gls	15-30	"
Everett gsl	15-30	"
Fitch gsl	8-15	63019
Fitch gsl	15-30	61319
Grove cobbly sl	15-30	"
Grove gsl	15-30	"
Grove vgsl	15-30	"
Hoypus cosl	15-30	61322
Hoypus gls	15-30	"
Indianola fsl	15-30	61319
Indianola ls	15-30	"
Indianola sl	15-30	"
Jolley vgl	15-30	"
Keystone ls	15-30	61322
Kickerville sil	15-30	61319
Klaus gl	15-30	61322
Klaus gsl	15-30	61322
Klaus sl	15-30	"
Lystair ls	8-15	61319
Lystair sl	15-30	"
Lynden ls	15-30	"
Lynden sl	15-30	"
Skykomish cobbly sl	15-30	"
Skykomish gsl	15-30	"
Smith Creek gl	15-30	"
Thornwood gl	8-15	"
Thornwood gl	15-30	"
Thornwood gsl	15-30	"
Tumwater lfs	15-30	61318

Land Capability Units VIew21, 23, 26 (VIe2) consist of moderately deep to shallow, moderately well drained, moderately coarse, medium, and moderately fine textured glacial terrace upland soils overlying cemented glacial till and bedrock. The soils occur on undulating and hilly topography, with slope gradients ranging from 3 to 30 percent. The surface water runoff is rapid, and the erosion hazard is moderate to severe.

Management problems are erosion, and wetness which is evident by seeps and wet basins. The soils are suited for growing grasses, legumes, and wood crops. Continuous grass, legume or woodland cover is necessary to adequately protect the soils against very severe erosion and sediment sources, to protect the water quality of the streams, and to stabilize the hydrology of the watersheds. The soils should be cultivated only to the extent necessary to reestablish grass, legume, or woodland cover. Generally, the soils are best suited for woodland, wildlife, and recreational purposes.

Mapping Unit	% Slope	ADP Code
Agnew fsl	15-30	61223
Agnew sl	15-30	"
Agnew sicl	15-30	"
Alderwood fsl	15-30	61221
Alderwood gl	15-30	"
Alderwood gsl	15-30	"
Alderwood gsl, shallow phase	15-30	"
Alderwood l	15-30	"
Alderwood ls	3-8	"
Alderwood ls	15-30	"
Alderwood stl	3-8	"
Alderwood stl	8-15	"
Alderwood stl	15-30	"
Clallam gsl	15-30	61223
Cloquallum sil	15-30	61221
Colvos fsl	3-8	"
Colvos fsl	15-30	"
Colvos fsl-Everett gsl	3-8	"
Colvos fsl-Everett gsl	15-30	"
Delphi gl	15-30	61221
Elwha l	15-30	61223
Hale sil	15-30	61221
Heisler gl	8-15	"
Heisler gl	15-30	"
Heisler shaly l	15-30	"
Heisler stl	15-30	"
Kapowsin gcl	15-30	"
Kapowsin gl	15-30	"
Kapowsin gsl	15-30	"
Kitsap gl	15-30	"
Kitsap sil	15-30	"
Labounty-McKenna sil	15-30	"
Oso l	8-15	"
Oso l	15-30	"
Oso l	3-8	"
Prather sicl	15-30	"
Quilcene sicl	15-30	"
Roche gl	15-30	"
Roche stl	15-30	"
Roche stsl	8-15	"
Schnorbush-Norma sil	8-15	"
Sinclair gfsl	15-30	61226
Sinclair gl	15-30	"
Sinclair gsl	15-30	"
Sinclair shotty l	15-30	"
Skiyou gl	15-30	"
Squalicum-Alderwood sil	15-30	61221
Squalicum-Alderwood stsil	15-30	"
Squalicum gsil	15-30	"
Squalicum sil	15-30	"
Squalicum stsil	15-30	"
Swantown gsl	0-3	61226
Swantown gsl	3-8	"
Swantown gsl	8-15	"
Whidbey gsl	15-30	"
Wilkeson sil	15-30	61221
Wilkeson l	15-30	"

Land Capability Units VIes17, 20, 21, 23, 24, and VIs16 (VIe3) consist of moderately deep to shallow, moderately well drained, moderately coarse, medium, and moderately fine textured glacial terrace upland soils overlying cemented glacial till and bedrock. The soils occur on undulating and hilly topography, with slope gradients ranging from 3 to 30 percent. The surface water runoff is rapid, and the erosion hazard is moderate to severe.

Management problems are sedimentation, water quality, erosion, and maintenance of soil structure and productivity, with the exception of Hoodsport gravelly sandy loam, 0 to 3 percent slopes, which has a problem of soil maintenance only. The soils are suited for growing grasses, legumes, and wood crops. Continuous grass, legume, or woodland cover is necessary to adequately protect the soils against a very severe erosion hazard. The soils should be cultivated only to the extent necessary to reestablish grass and legume cover. While grasses and legumes are grown on these soils, they are better suited for wood crop production, wildlife and recreational purposes.

AD-A037 573 PACIFIC NORTHWEST RIVER BASINS COMMISSION VANCOUVER WASH F/G 8/6
COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
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Land Capability Units VIes17, 20, 21, 23, 24, and VIs16 (VIe3) (Con.)

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Cathcart gl	15-30	61320	Giles sil, g sub-	15-30	61320	Hoodsport vgsl	8-15	61324
Cathcart gsil	15-30	"	soil phase			Hoodsport vgsl	15-30	"
Cathcart l	15-30	"	Harstine gsl	8-15	"	San Juan stl	15-30	61317
Cathcart stl	8-15	"	Harstine gsl	15-30	"	Saxon sil	15-30	61320
Cathcart stl	15-30	"	Heisler gl	3-8	"	Schnorbush l	15-30	"
Clallam gl	15-30	61323	Hoodsport gsl	0-3	63016	Shelton gsl	15-30	61324
Dabob vgsl	3-8	61320	Hoodsport gsl	8-15	61324	Tenino gsl	15-30	61321
Dabob vgsl	15-30	"	Hoodsport gsl	15-30	"	Townsend sl	15-30	61317
Giles fsl	15-30	"	Hoodsport stsl	8-15	"			
Giles l	15-30	"	Hoodsport stsl	15-30	"			

Land Capability Unit VIes25 (VIe4) consists of soils and land forms that are extremely variable in depth. They range from very shallow to deep, and overlie bedrock consisting of sandstone, basalt, and shale. Slopes of the area range between 3 and 30 percent. The surface water runoff is rapid, and the erosion hazard is moderate to severe.

Management problems are erosion, sedimentation, hydrology, maintenance of soil structure, and water intake. The soils are suited for growing grasses and legumes for hay and pasture, and wood crops. Generally, the lands are used for wood crop production. Where used for hay and pasture, they can be protected against erosion and deterioration by growing grasses and legumes until such time as the grasses and legumes require renovation or reseeding. However, they are best suited for wood crop production, wildlife, and recreational purposes.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Astoria sil	8-15	61325	Melbourne stl	15-30	61325	Rough mountainous	15-30	61325
Astoria sil	15-30	"	Olympic sicl	15-30	"	land		
Marblemount stl	15-30	"	Olympic stcl	8-15	"	Tebo gl	8-15	"
Melbourne i	0-3	"	Olympic stcl	15-30	"	Tebo gl	15-30	"
Melbourne l	3-8	"	Pickett r outcrop	15-30	"	Tebo l	15-30	"
Melbourne sicl	15-30	"	complex					
Melbourne stl	8-15	"						

Land Capability Unit VIes27 (VIe5) consists of soils that are variable in depth, rocky, or very gravelly, with moderate to steep slopes between 8 and 30 percent. They have formed on conglomerate, granite or serpentine rocks in areas of high rainfall.

Management problems are erosion and sediment control, and maintenance of soil structure. The soils are suited for growing grasses and legumes for hay and pasture, and for wood crop production. Generally, the lands are best suited for wood crop production, wildlife and recreational uses, and watershed protection. Where used for hay and pasture, the soils can be protected against erosion and deterioration by maintaining them in grasses and legumes until such time as these crops require renovation or reseeding.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Discovery Bay gsl	15-30	61327	Fidalgo rl	8-15	61327	Roche-rock complex	15-30	61327
Discovery Bay gsl-	15-30	"	Fidalgo rl	15-30	"			
r outcrop complex			Olele vgsil	15-30	"			

Land Capability Unit VIew28 (VIe6) consists of shallow and moderately deep (20 to 36 inches), poorly and imperfectly drained, moderately fine, and fine textured soils overlying dense glacial clay till. They occur on rolling to steep topography, with slope gradients ranging between 3 and 30 percent. The surface water runoff is rapid, and the erosion hazard is severe. Free water accumulates in the soil over the dense basal till, and may move laterally and surface as seep spots at lower elevations.

Management problems are erosion, sedimentation, and wetness. The soils are suited for growing grasses, legumes, and wood crops. Areas seeded to grasses and legumes should remain in this type of cover until such time as the seeding deteriorates and needs renovation. The soils should then be cultivated only to the extent necessary to reestablish the grass and legume cover. The soils are well suited for wood crop production, wildlife, and watershed protection.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Bow cl	15-30	61228	Bow sil	15-30	61228	Coveland stsil	8-15	61228
Bow gl	15-30	"	Bow stsil	3-8	"	Stossel stl	15-30	"
Bow gsil	15-30	"	Casey fsl	15-30	"	Whatcom sil	15-30	"
Bow l	15-30	"	Casey l	15-30	"			

Land Capability Unit VIws19 (VIw1) consists of excessively drained, coarse textured alluvial soils, subject to frequent overbank flow flooding. Their surfaces consist of sands, loamy sands, fine sands, loamy fine sands, gravelly loamy sands, sandy loams and loams, with an acidity ranging from pH 5.1 to 6.5. Their subsoils are coarse textured sands, and they overlie sands, or gravelly and cobbly sands.

Management problems are wetness from overbank flow flooding and stabilization of soils against streambank erosion. The soils are suited for wildlife and recreational uses. However, the land is best suited for growing cottonwood, which is one of the most effective means of stabilizing the soils against streambank erosion and channeling. Areas protected by levees are suited for growing grasses and legumes for hay and pasture. Grasses and legumes should remain as a permanent cover on the land until such time as renovation is necessary.

Land Capability Unit VIws19 (VIw1) (Con.)

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Edgewick s	0-3	62319	Newberg lfs	0-3	62319	Pilchuck lfs, shallow	0-3	62319
Juno gsl	0-3	"	Newberg ls	0-3	"	Pilchuck ls	0-3	"
Juno l	0-3	"	Pilchuck fs	0-3	"	Pilchuck sl	0-3	"
Juno ls	0-3	"	Pilchuck gls	0-3	"			
Juno sl	0-3	"	Pilchuck lfs	0-3	"			

Land Capability Units VIs10, 12, 13, and VIse13 (VIs1) consist of deep, somewhat excessively drained, moderately coarse, and coarse textured glacial outwash soils on slope gradients generally of less than 8 percent. Their subsoils consist of sands and loamy sands; some have gravel, cobbles and stones mixed through the sands. The surface water runoff is slow, and the erosion hazard is slight.

The primary management problems are maintaining soil structure and water intake rates. Minor areas of soils on 8 to 15 percent slope have been included because the recommended management will control erosion and sediment on soils with rapid permeabilities. The soils are fairly well suited for growing grasses, legumes, and wood crops. Grasses and legumes should be permanent, with only sufficient cultivation to reseed desired grasses and legumes. Generally, under common-level management, the yields, where harvested for hay, range between 1.5 and 1.8 tons per acre. Low water-holding capacities seriously limit production of hay or other crops, and yields are low on these soils. Water requirements are high, and crop yields are too low to fully justify irrigation for top production under 1968 economic conditions. The soils are well suited for wildlife and recreational uses.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Carlsborg gsl	0-3	63010	Greenwater ls	8-15	63113	Klaus gl	8-15	63113
Chimacum gl	3-8	63012	Hoypus cosl	0-3	63012	Klaus gsl	0-3	63012
Chimacum gsl	3-8	"	Hoypus cosl	8-15	63013	Klaus gsl	3-8	"
Chimacum vgls	8-15	63113	Hoypus gls	0-3	63012	Klaus gsl	8-15	63113
Cispus pumicy sl	0-3	63012	Hoypus gls	3-8	"	Klaus sl	0-3	63012
Dick ls complex	3-8	"	Hoypus gls	8-15	63013	Klaus sl	3-8	"
Dick ls	8-15	63113	Keystone fsl	0-3	63012	Klaus sl	8-15	63013
Greenwater ls	0-3	63012	Keystone ls	0-3	"	Neptune gsl	3-8	63010
Greenwater ls	3-8	"	Keystone ls	8-15	63113	Pondilla fs	0-3	63012
Greenwater s	3-8	"	Klaus gl	0-3	63012	Ragnar fsl	15-30	63113
Greenwater sl	0-3	"	Klaus gl	3-8	"			

Land Capability Units VIs01, 14, 18, and VIse15, 17 (VIs2) consist of moderately deep, excessively drained, gravelly soils in the high rainfall area (50 to 70 inches). Most slopes are less than 8 percent. Surface soils are sandy loams and loamy sands; some are gravelly. Subsoils are very gravelly sandy loams or loamy sands. The surface water runoff is slow, and the erosion hazard is slight, except on slopes of 8 to 15 percent, where it is moderate.

The primary management problems are maintaining soil structure and water intake rates. These soils are fairly well suited for growing grasses, legumes, and wood crops. Grasses and legumes should be permanent, with only sufficient cultivation to reseed desired grasses and legumes. Generally, under common-level management, the yields where harvested for hay range between 1.5 and 1.8 tons per acre. Low water-holding capacities seriously limit production of hay or other crops, and yields are low on these soils. Water requirements are high, and crop yields are too low to fully justify irrigation for top production under 1968 economic conditions. While rapidly permeable soils on 8 to 15 percent slopes are included here, the recommended management practices are adequate to protect the land against erosion and sedimentation. The soils are well suited for wildlife and recreational uses.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Barneston gls	8-15	63117	Grove stsl	0-3	63014	Skykomish cobbly sl	0-3	63018
Everett cobbly sl	0-3	63018	Grove vgsl	3-8	"	Skykomish cobbly sl	3-8	"
Everett gls	0-3	"	Indianola ls	0-3	63018	Skykomish cobbly sl	8-15	"
Everett gls	3-8	"	Indianola ls	3-8	"	Skykomish gl	3-8	"
Everett gls	8-15	"	Indianola sl-Roche	3-8	"	Skykomish gsl	3-8	"
Everett gsl	0-3	"	l complex			Skykomish gsl	8-15	"
Everett gsl	3-8	"	Indianola sl-Roche	8-15	63117	Snoqualmie gls	3-8	63001
Everett gsl	8-15	63117	l complex			Snoqualmie gsl	3-8	"
Fitch gsl	0-3	63001	Lynden ls	0-3	63018	Snoqualmie gsl,	3-8	"
Fitch gsl	3-8	"	Lynden ls	3-8	"	terrace phase		
Grove cobbly sl	0-3	63014	Lynden ls	8-15	63117	Thornwood gl	0-3	63018
Grove cobbly sl	8-15	63115	Lynden sl	0-3	63018	Thornwood gl	3-8	"
Grove gsl	0-3	63014	Lystair ls	3-8	63014	Thornwood gsl	0-3	"
Grove gsl	3-8	"	Lystair sl	3-8	"	Thornwood gsl	3-8	"
Grove gsl	8-15	63115	Lystair sl	8-15	63115	Thornwood gsl	8-15	63117

Land Capability Units VIs21 and VIse21 (VIs3) consist of moderately deep, moderately coarse or coarse textured, excessively drained soils formed in gravelly outwash or alluvium. Surface soils are dark colored sands, gravelly loams, or sandy or stony loams, relatively high in organic matter. Subsoils are very gravelly loams, sandy loams, or loamy sands with rapid permeabilities. Runoff is slow, and wind and water erosion hazards are slight.

The primary management problems are maintenance of soil structure and water intake rates. Slight erosion and sedimentation may be problems on hilly areas; however, the recommended conservation measures adequately protect soils against deterioration. The soils are fairly well suited for growing grasses, legumes, and wood crops. Grasses and legumes should be permanent, with only sufficient cultivation to reseed them. Generally, under common-level management, the yields, where harvested for hay, range between 1.5 and 1.8 tons per acre. Low water-holding capacities seriously limit the production of hay or other crops, and yields are low on these soils. Water requirements are high, and crop yields are too low to fully justify irrigation for top production under 1968 economic conditions. The soils are well suited for wildlife and recreational uses.

Land Capability Units VIs21 and VIse21 (VIs3) (Con.)

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Carstairs gl	0-3	63021	San Juan gsl	3-8	63021	Spanaway gsl	15-30	63121
Nisqually s	3-8	"	San Juan gsl	15-30	63121	Spanaway stl	0-3	63021
San Juan cosl	0-3	"	San Juan stsl	3-15	"	Spanaway stl	8-15	"
San Juan cosl	8-15	"	San Juan stsl	15-30	"			

Land Capability Units VIIew30, 33 (VIIe1) consist of well drained and moderately well drained, moderately deep, deep, and shallow soils overlying bedrock, cemented glacial till or dense lacustrine materials, all of which limit root and water penetration. The soils occur on steep slopes which generally exceed 30 percent gradient. Their surfaces consist of medium, moderately coarse, or moderately fine textured soils. Some have stony and rocky phases. Their subsoils consist mostly of medium and moderately fine textured materials or stony and rock phases which grade into the underlying substrata of cemented glacial till, dense lacustrine materials or bedrock at depths ranging from less than 1 foot to 5 feet or more. The surface water runoff is rapid, and the erosion hazard is severe.

Management problems are erosion and sedimentation, and wetness, which may occur as a seasonal water table, or as seep areas. The soils are best suited for growing Douglas-fir, western hemlock and red alder for wood products. They are too steep for other agricultural uses. They are well suited for wildlife and recreation. Woodland cover and careful management are necessary on steep and very steep slopes to prevent erosion and sedimentation, and to maintain water quality.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Alderwood gl	30-45	71230	Discovery Bay vgsl	15-30	71230	Oso l	30-45	71230
Alderwood gsl	30-45	"	Discovery Bay-rock outcrop complex	30-45	"	Prather sicl	30-45	71233
Colvos fsl	30-45	"				Quilcene sicl	30-45	71230
Colvos-rock outcrop complex	30-45	"	Jolley vgl	30-45	"	Squalicum gsil	30-45	"
			Kitsap sil	30-45	"	Squalicum sil	30-45	"

Land Capability Units VIIes30, 34 (VIIe2) consist of well drained and moderately well drained, moderately deep, deep, and shallow soils overlying bedrock, cemented glacial till, or dense lacustrine materials, all of which limit root and water penetration. The soils occur on steep slopes which generally exceed 30 percent gradient. Their surfaces consist of medium, moderately coarse, or moderately fine textured soils. Some have stony and rocky phases. Their subsoils consist mostly of medium and moderately fine textured materials or stony and rock phases which grade into the underlying substrata of cemented glacial till, dense lacustrine materials or bedrock at depths ranging from less than 1 foot to 5 feet or more. The surface water runoff is rapid, and the erosion hazard is severe.

Management problems are erosion and sediment control, and maintenance of soil structure and water intake rates. The land is too steep for agricultural uses, other than for growing Douglas-fir, western hemlock and red alder for wood products. The soils are suited for wildlife, recreational and watershed protection purposes.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Discovery Bay gsl	30-45	71330	Hoypus gls	30-45	71334	Skiyou gl	30-45	71334
Discovery Bay vgsl	30-45	"	Sinclair gsl	30-45	"			

Land Capability Units VIIew31, 32 (VIIe3) consist of moderately deep and deep, well and moderately well drained soils, on upland marine terraces and glacial till with slopes over 30 percent. The surface soils are medium to moderately fine textured, and the subsoils are compact, fine and medium textured materials. The runoff is rapid, and the erosion hazard is severe.

Management problems are control of erosion and sedimentation, and wetness, which occurs as excess water in the soil profiles overlying restrictive layers. The soils are best suited for growing Douglas-fir, western hemlock and red alder for wood products. Except for woodlands, wildlife, recreation, and watershed protection, the soils are too steep for agricultural uses.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Agnew sicl	30-45	71232	Bow sil	30-45	71231	Whatcom sil	30-45	71231
Bow gl	30-45	71231	Clallam l	30-45	71232			

Land Capability Unit VIIes33 (VIIe4) consists of deep, well drained, moderately fine and medium textured soils on steep slopes over 30 percent. The subsoils are moderately fine textured; some are gravelly. The runoff is rapid, and the erosion hazard is severe.

Management problems are erosion and sediment control, and maintenance of soil structure and water intake rates. These soils are best suited for growing Douglas-fir, western hemlock and red alder for wood products, and for wildlife, recreation, and watershed protection uses.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Melbourne sicl	30-45	71333	Olympic sicl	30-45	71333	Tebo gl	30-45	71333

Land Capability Unit VIIes35 (VIIe5) consists of shallow to moderately deep, very gravelly, stony or rocky soils formed in residual material or glacial till in areas of high rainfall (45 to 70 inches). Slopes are usually more than 30 percent, but some 8 to 15 percent areas are included. The runoff is medium to rapid, and the erosion hazard is slight to severe.

Management problems are erosion and sediment control, and maintenance of soil structure and water intake rates. The soils are best suited for growing Douglas-fir, western hemlock and red alder for wood products, and they are also well suited for wildlife, recreational, and watershed protection purposes.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Ahl sil complex	30-45	71335	Cathcart stl	30-45	71335	Olele vgsil	8-15	71335
Ahl vgsil	30-45	"	Fidalgo rl	30-45	"	Olele vgsil	30-45	"
Cathcart gl	30-45	"	Heisler stl	30-45	"	Pickett rsil	30-45	"
Cathcart gsil	30-45	"	Hoodsport gsl	30-45	"	Shelton gsl	30-45	"
Cathcart l	30-45	"	Kickerville sil	30-45	"			

Land Capability Unit VIIes29 (VIIe6) consists of deep, somewhat excessively drained, moderately coarse and coarse textured glacial outwash terrace soils on steep topography, with slope gradients ranging between 8 and 50 percent. Their surfaces consist of coarse, moderately coarse, gravelly, very gravelly, cobbly and stony textures, with acidity ranging between pH 5.1 and 6.0. Their subsoils and substrata consist of sands and gravelly, very gravelly, cobbly, stony sands. The surface water runoff is medium to rapid, and the erosion hazard is severe to very severe.

Management problems are erosion and sedimentation control, and maintenance of soil structure to protect the water intake rates. The soils are best suited for growing Douglas-fir for wood crops. They are also well suited for wildlife, recreational, and watershed protection purposes.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Barnhardt gsl	30-45	71329	Everett stsl	8-15	71329	Grove vgsl	30-45	71329
Corkindale l	30-45	"	Everett stsl	15-30	"	Indianola ls	30-45	"
Everett gsl	30-45	"	Everett stsl	30-45	"	Keystone ls	30-45	"
Everett stls	8-15	"	Grove gsl	30-45	"	Thornwood gsl	30-45	"

Land Capability Unit VIIes36 (VIIe7) consists of rough broken or stony and mountainous lands, and rock lands. The soils have variable depths and textures. They are usually shallow, but some deep areas occur. Slopes generally are over 30 percent, and many are 65 percent and more. The runoff is rapid, and the erosion hazard is slight to severe.

These are miscellaneous land types. Some timber is grown, but the soils are used mainly for wildlife and water yield areas.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Ahl r complex	30-45	71336	Rough broken land, schist bedrock	30-45	71336	Rough broken land, st to extremely r	15-30	71336
Roche-rock rl complex	30-45	"	Rough broken land, st	30-45	"	Rough broken rocky	30-45	"
Rock lands	30-45	"	Rough broken land, st complex	30-45	"	Rough stony land	30-45	"
Rock lands, r	8-15	"	Rough broken land, st to cobbly	30-45	"	Steep broken land	30-45	"
Rough broken land	30-45	"	Rough broken land, st to extremely r	30-45	"			
Rough broken land complex	30-45	"						
Rough broken land, r to extremely r	30-45	"						

Land Capability Unit VIIws20 (VIIw1) consists of deep, excessively drained, coarse textured, bottom land soils. Their surfaces consist of sands and gravelly sands, and their subsoils and substrata are sands, gravels, and cobbles. They have very severe limitations, due to frequent overflow and very low water-holding capacity of the coarse textures. The surface water runoff is slow.

Management problems are wetness due to streambank overflow flooding, and maintenance of soils against streambank cutting and sedimentation. The soils are best suited for growing cottonwood, which protects them against streambank erosion and channeling. They are also well suited for limited wood crop production, wildlife, and recreational uses.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Pilchuck gs	0-3	72320	Pilchuck s	0-3	72320			

Land Capability Unit VIIs23 (VIIs1) consists of somewhat excessively drained, moderately deep, and deep, coarse textured, glacial outwash soils on slopes of less than 8 percent gradient. Their surfaces consist of stony sandy loams and stony sands, with an acidity range between pH 5.6 and 6. Their subsoils and substrata consist of loose, stony, gravelly sands. The surface water runoff is slow, and the erosion hazard is slight.

The primary management problem is the protection of soil structure and water intake rates. The soils are best suited for growing Douglas-fir for wood crops. They are also well suited for recreation, wildlife, and watershed protection uses.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Everett stsl	0-3	73023	Skykomish stl	3-8	73023	Skykomish sts	3-8	73023
Skykomish gs	3-8	"						

Land Capability Unit VIIes37 (VIIe1) consists of miscellaneous land types that, because of extreme erosion limitations, are suited only for growth of vegetation to provide watershed protection, and for wildlife use. The soils are very shallow, stony and rocky. Soil materials are extremely unstable, and require all possible vegetation to hold them on the land, to give adequate protection against sedimentation, and to prevent destruction of wildlife food and cover.

The lands are best suited for upland game, recreational uses, and enjoyment of their scenic beauty.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Discovery Bay vgsl	50-80	81337	Olele vgsil	65+	81337			

Land Capability Unit VIIes38 (VIIe2) is made up of active sand dunes, which consist of deep and coarse textured sand; there is no true soil present. They may need stabilization practices to prevent wind erosion.

The lands have little use except as wildlife or recreational areas.

Mapping Unit	% Slope	ADP Code
Active sand dunes		81338

Land Capability Units VIIIew39; ws00, 22, 23, 24; s00 (VIIIw1) consist of soils and miscellaneous land types that vary from coastal beach to moss peat. There is great variation in water-holding capacity, but all have limitations related to wetness or overflow, or to the soil conditions within the units.

Many of the soils are useful for wildlife food and cover, and for recreational areas.

Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code	Mapping Unit	% Slope	ADP Code
Coastal beach		81239	Marsh complex		82323	Spalding peat		82324
Fresh water marsh		82322	Orcas peat		82324	Tidal marsh		82323
Gravel pits		83000	Orcas peat, shallow/ gravel		"			
Greenwood peat		82324						
Made land		83000	Riverwash		82300			

1/ Soil symbols used:

c	clay	r	rocky
co	coarse	s	sandy
f	fine	sl	silt
g	gravelly	st	stony
l	loam	v	very

* An asterisk indicates a benchmark soil. A benchmark soil is one that, because of its great extent or key position in the soil classification system, or both, is important in determining and understanding the variety of soil conditions in a State or other area.

EXHIBIT 2-2. Woodland suitability groupings of soils with interpretations for management and treatment, Puget Sound Area

Soil and Group Description 1/	Slope Classes 2/	Erosion Hazard 3/	Equipment Limitations 4/	Windthrow Hazard 5/	Potential Soil Productivity Average site index 6/ Douglas-fir	Potential Soil Productivity Average site index 6/ Red alder	Potential for Minor Understory Forest Products 7/	For Douglas-fir Brush Encroachment 8/	For Douglas-fir Christmas tree Potential 9/
Group 1. Moderately deep and deep well drained and somewhat excessively drained terrace and bottomland soils with medium and moderately coarse textured surfaces, moderately coarse textured subsoils, and coarse textured substrata. Permeability is moderately rapid in the subsoils and rapid in the substrata. Annual precipitation is 70 to 120 inches.	A and B	Slight	Slight	Slight	182 (4)	95-104*	Medium	Moderate	Low
	C and D	Moderate	Moderate						
	E and over	Severe	Severe						
				Soils of Woodland Suitability Group 1 are: Sol Duc gl and gsl. 10/					
Group 2. Deep, well drained and moderately well drained glacial terrace and upland soils with medium and moderately coarse textured surfaces and subsoils. Permeability is moderate to moderately rapid. Annual precipitation ranges between 35 to 65 inches.	A and B	Slight	Slight to Moderate	Slight	171 +6 (21)	106 (1)	Medium	Moderate to Severe	Low
	C and D	Moderate	Moderate						
	E and over	Severe	Severe						
				Soils of Woodland Suitability Group 2 are: Giles l, sil, g (subsoil), fsl, and sl; Giles-Tromp Complex; Indianola sl (compact substratum); fsl, ls (compact substratum); Lynden l; Lystair sl; and Oso l, sl and sl (deep).					
Group 3. Moderately deep and deep, moderately well drained and well drained upland and glacial terrace soils with medium, moderately coarse and moderately fine textured surfaces, medium, moderately coarse and moderately fine textured subsoils, and overlying bedrock, cemented glacial till or fine textured substrata. Permeability is moderate to moderately slow in the subsoils and slow to very slow in the substrata. Few fine roots penetrate the substrata. Annual precipitation is 40 to 70 inches.	A and B	Slight to Moderate	Moderate to severe	Moderate	160 +5 (68)	99 (1)	Low to Medium	Moderate to Severe	Low
	C and D	Moderate	Severe						
	E and over	Severe	Severe						
				Soils of Woodland Suitability Group 3 are: Alderwood l, sil; Bow l, sil, gl, cl, sicl; Cathcart l, cl, gl, sil; Enumclaw l, fsl, sl; Fidalgo rl; Heisler gl, l (shaly), stl; Jolley vgl; Kapowsin gl, gcl; Kickerville sil; Kitsap l, sil, sicl; Kline l, gl; La Bounty sil; Marblemount stl; Melbourne l; Saxon sil; Schnorbush l; Shelton gl; Squalicum sil, gsil; Tebo l, gl, sicl; Whatcom sil; and Wilkeson l and sil.					

* "Starred" values are adjusted values which more nearly represent the true average site index, in the best judgment of the authors, where adequate site index information was not available.

Exhibit 2-2 Woodland suitability groupings of soils with interpretations for management and treatment, Puget Sound Area. **(continued)**

Soil and Group Description 1/	Slope Classes 2/	Erosion Hazard 3/	Equipment Limitations 4/	Windthrow Hazard 5/	Potential Soil Productivity Average site index 6/ Douglas-fir	Potential Soil Productivity Average site index 6/ Red alder	Potential for Minor Understory Forest Products 7/	For Douglas-fir Brush Encroachment 8/	For Douglas-fir Christmas tree Potential 9/
Group 4. Deep, somewhat excessively drained glacial terrace soils with medium and moderately coarse textured surfaces and moderately coarse textured subsoils. Permeability of the subsoils is rapid. Annual precipitation ranges between 35 and 55 inches.	A and B	Slight	Slight	Slight	160 ±6 (20)		Low to Medium	Slight to Moderate	Low to Medium
	C and D	Moderate	Moderate						
	E and over	Severe	Severe						
				Soils of Woodland Suitability Group 4 are: Barneston sil; Corkindale l; Everett gl, gsl; Klaus sl, gl, gsl; Kline sil, sl; Snoqualmie gsl, gl; Thornwood gl; and Wickersham l (shaly).					
Group 5. Deep and moderately deep, well drained and moderately well drained glacial terrace and upland soils with medium, moderately fine and moderately coarse textured surfaces and subsoils, and overlying cemented glacial till, clay till or bedrock. Permeability is slow to moderate in the subsoils and very slow to slow in the substratum. Annual precipitation ranges between 35 to 70 inches.	A and B	Slight	Moderate	Moderate	145 ±8 (100)	84 (1)	Medium	Moderate to Severe	Low
	C and D	Moderate	Severe						
	E and over	Severe	Severe						
				Soils of Woodland Suitability Group 5 are: Alderwood gsl, gl, stl; Cathcart gsl, fsl, stl; Discovery Bay gsl; Gilligan l, sil, sil (shallow), gl (shallow); Harstine gsl: Kapowsin gsl; Nordby l; Orting l, sl, gsl, stsl; Pickett-Rock complex; Quilcene sicl; Shelton gsl; Skiyou gl; and Squalicum stsil.					
Group 6. Shallow and moderately deep, poorly drained and imperfectly drained glacial basin soils with medium and moderately coarse textured surfaces, iron cemented subsoils, and coarse textured substrata. Permeability of the subsoil is slow to very slow. Annual precipitation is 40 to 50 inches.	A and B	Slight	Slight	Moderate	140 ±2 (3)		Medium	Severe	Severe
	C and D	Moderate	Moderate						
				Soils of Woodland Suitability Group 6 are: Cagey gl, gfsl, gsl, sil, sl; Custer sil, fsl, sl; Edmonds l, sil, sl, fsl; Hale sil; Hale-Norma complex; Hemmi sil; Tromp sil, sicl; and Woodlyn sil.					
Group 7. Deep, excessively drained and somewhat excessively drained glacial terrace soils with moderately coarse textured surfaces and coarse textured subsoils. Permeability is rapid to moderately rapid. Annual precipitation is 35 to 65 inches.	A and B	Slight	Slight	Slight	137 ±8 (67)	96 (2)	Low to Medium	Slight to Moderate	Low to Medium
	C and D	Moderate	Moderate						
	E and over	Severe	Severe						
				Soils of Woodland Suitability Group 7 are: Barneston gsl; Dick lfs; Everett sl (cobbly), stsl, gls, Grove gl (basin), l, gl, sl, gsl (basin); Indianola sil, sl; Lynden sl, gl, gsl; Nisqually s, ls; Ragnar fsl; Skykomish gsl, sl (cobbly), gl, stl; Smith Creek gl; Spanaway gsl; Tenino gsl; Thornwood gsl; and Tumwater fsl, lfs.					

Exhibit 2-2 Woodland suitability groupings of soils with interpretations for management and treatment, Puget Sound Area. **(continued)**

Soil and Group Description 1/	Slope Classes 2/	Erosion Hazard 3/	Equipment Limitations 4/	Windthrow Hazard 5/	Potential Soil Productivity Average site index 6/ Douglas-fir	Potential Soil Productivity Average site index 6/ Red alder	Potential for Minor Understory Forest Products 7/	For Douglas-fir Brush Encroachment 8/	For Douglas-fir Christmas tree Potential 9/
Group 8. Moderately deep, well drained and somewhat excessively drained glacial terrace and upland soils with medium textured and moderately coarse textured surfaces and subsoils overlying cemented glacial till or bedrock. Permeability is moderate to rapid. Average annual precipitation ranges between 48 and 65 inches.	A and B	Slight	Slight to Moderate	Moderate	130 ±6 (28)		Low to Medium	Moderate	Medium
	C and D	Moderate	Moderate						
	E and over	Severe	Severe						
				Soils of Woodland Suitability Group 8 are: Delphi gl; Hoodsport gsl, vgsl, stsl; Olete vgsil; and Whidbey gsl.					
Group 9. Moderately deep to shallow, poorly drained and imperfectly drained glacial terrace and upland soils with moderately fine and medium textured surfaces and moderately fine and fine textured subsoils. Some soils have cemented glacial till or bedrock substrata. Permeability is slow to very slow. Annual precipitation ranges between 25 and 45 inches.	A and B	Slight	Moderate	Moderate	114 ±11 (23)	81 (1)	Low	Moderate to Severe	Low to Medium
	C and D	Moderate	Severe						
	E and	Severe	Severe						
				Soils of Woodland Suitability Group 9 are: Bow 1 (shallow), sil, sil (shallow), gsil, stsil; Buckley 1, sil; Casey 1, fsl, sil; Cloquallum sil, sicl; Coveland l, sil, gl, gsil, stsil; Kitsap sicl, gl; and Stossel cl, stl.					
Group 10. Moderately deep, deep and shallow, well drained and moderately well drained glacial terrace soils with medium and moderately coarse textured surfaces, moderately coarse textured subsoils, and cemented glacial till substrata. Permeability of the subsoils is moderately rapid and the substrata is slow. Few roots penetrate into the substrata. Annual precipitation is 25 to 65 inches	A and B	Slight	Moderate	Moderate	106 ±7 (57)	75-84*	Low to Medium	Slight to Moderate	Low to Medium
	C and D	Moderate	Severe						
	E and over	Severe	Severe						
				Soils of Woodland Suitability Group 10 are: Agnew sil, sicl; Alderwood gsl (red phase), gsl, gsl (shallow), gl (shallow), ls; Bozarth fsl; Clallam l, gl, gsl; Cloquallum sil (moderately shallow); Discovery Bay vgsl; Grove gsl, vgsl; San Juan stl (moderately deep), gsl (moderately deep); Sinclair l (shotty), cl (shotty), gsl, gfsl, gl; Swantown l, gsl; Tokul gsl; Townsend l, sl, gl; and Whidbey gsl.					
Group 11. Deep, somewhat excessively drained glacial terrace soils with moderately coarse and coarse textured surfaces, and coarse textured subsoils. Permeability is rapid. Annual precipitation ranges between 35 to 70 inches	A and B	Slight	Slight	Slight	109 ±6 (66)		Medium to High	Slight	High
	C and D	Moderate	Moderate						
	E and over	Severe	Severe						
				Soils of Woodland Suitability Group 11 are: Barneston gfsl; Carstairs gl; Chimacum gl. gsl; Dick ls, ls (complex); Everett stls; Fitch gsl; Hoypus cosl, gls; Indianola ls, lfs; Keystone fsl, ls; Lynden ls; Lystair fsl, ls; San Juan cosl, gsl, stsl; Skykomish gs, sts; and Snoqualmie gls.					

Exhibit 2-2 Woodland suitability groupings of soils with interpretations for management and treatment, Puget Sound Area. (continued)

Soil and Group Description 1/	Slope Classes 2/	Erosion Hazard 3/	Equipment Limitations 4/	Windthrow Hazard 5/	Potential Soil Productivity Average site index 6/ Douglas-fir	Potential Soil Productivity Average site index 6/ Red alder	Potential for Minor Understory Forest Products 7/	For Douglas-fir Brush Encroachment 8/	For Douglas-fir Christmas tree Potential 9/
Group 12. Moderately deep, moderately well drained, glacial terrace soils with medium and moderately coarse textured surfaces, and moderately fine textured subsoils. Permeability is slow. Annual precipitation is 22 to 28 inches.	A and B	Slight	Moderate	Moderate	108 ±10 (44)	75 (8)	Low	Moderate	Medium
				Soils of Woodland Suitability Group 12 are: Elwha l; Roche l, gsl, gl, stl, stsl; and Roche-Rock complex.					
Group 13. Deep, somewhat excessively drained glacial terrace soils with very gravelly and cobbly moderately coarse textured surfaces and subsoils, and coarse textured substrata. Permeability is rapid to very rapid. Annual precipitation is 70 to 100 inches.	A and B	Slight	Slight	Slight	87 ±5 (4)		High	Slight	High
	C and D	Moderate	Moderate						
				Soils of Woodland Suitability Group 13 are: Grove vgsl, stsl, sl(cobbly).					
Group 14. Moderately deep, poorly drained upland and terrace soils with medium textured surfaces, and moderately fine and fine textured subsoils. Permeability is slow. Annual precipitation is 90 to 120 inches.	A and B	Slight	Severe						
	C and D	Moderate	Severe						
	E and over	Severe	Severe	Sitka Spruce, Western Hemlock, Western Red Cedar, and Red Alder are adapted to Hoko soils and Douglas-fir to Nasel soils.					
Group 15. Deep, excessively and somewhat excessively drained bottomland soils with moderately coarse and coarse textured surfaces, and coarse textured subsoils. Permeability is rapid to very rapid. Most of these soils are subject to overflow.	A and B	Moderate to Severe	Slight	Slight	Black cottonwood and Big Leaf Maple adapted to these soils.		Low	Moderate	Low
				Soils of Woodland Suitability Group 15 are: Edgewick s; Greenwater s; Pilchuck sl, fsl, ls, gls, fs, lfs, lfs (shallow), s, gs; and Riverwash.					
Group 16. Moderately deep and shallow, poorly drained bottomland and glacial basin soils with moderately coarse, medium, and moderately fine textured surfaces, and fine textured subsoils. Runoff is slow to very slow and permeability is very slow. Water remains on the surface 8 months or more unless drained. Where drained, these are agricultural soils.	A and B				131 10 ± (5)	82 (1)	Most suitable for Sitka Spruce, Western Red Cedar, Western Hemlock, Willows, and Sedges.		
				Soils of Woodland Suitability Group 16 are: Bellingham l, sicl, cl, sil, fsl, c, sic; Clipper sicl; Everson sil, fsl, cl; Hovde sicl, s, ls; Issaquah sil; Kopiah l, sicl; Lummi sil, sicl; McKenna l, sicl, gcl, gl; Norma l, cl, sl, sil, sicl, fsl, sic: Nookachamps sil, sicl; Nuby sil; Puget cl, c, sic; Reed sicl; Shuwah sicl; Skagit sicl; Snohomish l, sil, sicl, fsl, sic, lfs; Thornton c, sicl; Tisch sil, sicl; Wapato sil, sicl, cl; and Woodinville sil.					

Exhibit 2-2 Woodland suitability groupings of soils with interpretations for management and treatment, Puget Sound Area (continued)

Soil and Group Description 1/	Slope Classes 2/	Erosion Hazard 3/	Equipment Limitations 4/	Windthrow Hazard 5/	Potential Soil Productivity Average site index 6/ Douglas-fir	Potential Soil Productivity Average site index 6/ Red alder	Potential for Minor Understory Forest Products 7/	For Douglas-fir Brush Encroachment 8/	For Douglas-fir Christmas tree Potential 9/
Group 17. Deep somewhat excessively drained bottomland and low terrace soils with medium, moderately coarse and coarse textured surfaces, and coarse textured subsoils. Permeability is rapid to very rapid. Some of the soils are subject to periodic overflow. Annual precipitation ranges between 16 and 100 inches. The soils are droughty. Some are irrigated.							Most of these droughty soils have been cleared for cultivation. No tree productivity information is known to be available.		
				Soils of Woodland Suitability Group 17 are: Edgewick sil, fsl, vfsl; Greenwater sl, ls; National l (pumicy), sl (pumicy); Neptune sl; Newberg l, fsl, ls; Pilchuck sil; Puyallup sl, fsl, ls (over Puget), lfs; and Snakelum cosl.					
Group 18. Deep, moderately deep, and shallow, very poorly drained organic soils underlain by sand, silt or clay. Moderately to moderately slowly permeable. Very slow runoff.						101 (1)	Organic soils that generally are not suite to Douglas-fir, Alder, Hemlock and Shore Pine have been observed.		
				Soils of Woodland Suitability Group 18 are: Carbondale muck, muck (shallow); Dupont muck; Greenwood peat; Mukilteo peat; McMurray peat, peat (shallow); Orcas peat: Rifle peat (McMurray); Semiahmoo muck, muck (shallow), muck (shallow over Mukilteo);Spalding peat, peat (burned phase); Tacoma muck(shallow; Tanwax muck; and Tidal marsh.					
Group 19. Deep, well drained and moderately well drained bottomland and low terrace soils with medium and moderately fine and moderately coarse textured surfaces and subsoils. Permeability is moderate to moderately rapid. Annual precipitation is 20 to 70 inches. (Soils in this group are used mainly for agricultural purposes.)	A and B				173 (2)		Used mainly for agriculture. No tree production activity is known to be available.		
				Soils of Woodland Suitability Group 19 are: Belfast sil, sl; Chehalis sil; Cokedale l, sl, sil, sil (over Puyallup), sicl (over Puyallup); Coupeville l, sil; Dungeness l, sil; Ebeys sl; Eld l, sicl, gl; Nooksack sil, fsl; Puget l, sil, sicl, fsl, vfsl; Puyallup l, sil, sicl, sl (shallow over Buckley), vfsl; Salal sil, fsl; Samish sicl; Sammamish sil; Sauk l; Sequim gl; Sultan l, cl, sil, fsl; and Sumas sil.					

See following page for explanation of symbols.

Exhibit 2-2 Woodland suitability groupings of soils with interpretations for management and treatment, Puget Sound Area. (continued)

Soil Group and Description 1/	Slope Classes 2/	Erosion Hazard 3/	Equipment Limitations 4/	Windthrow Hazard 5/	Potential Soil Productivity Average site Index 6/ Douglas-fir	Potential Soil Productivity Average site Index 6/ Red alder	Potential for Minor Understory Forest Products 7/	For Douglas-fir Brush Encroachment 8/	For Douglas-fir Christmas tree Potential 9/

FOOTNOTES:

1/ See Table 3, Index of Mapping Units, for alphabetical listing of soils with their woodland soil groups.

2/ Ranges of slope gradients in percent, segregated and identitied as follows: A, 0-3%; B, 3-8%; C, 8-15%; D, 15-30%; E, 30-45%; F, 45% plus.

3/ Erosion Hazard: Slight - No special problem.
Moderate - Some measures required.
Severe - Intensive use of control measures.

4/ Equipment Limitations: Slight - No special problems.
Moderate - Restrictions during wet weather.
Severe - Long restricted periods.

5/ Windthrow Hazard: Slight - No special problems.
Moderate - Moderate thinning permissable.
Severe - Thinning may induce severe hazard.

6/ First figures denote average site index as determined from the sample data; second (plus or minus) figures indicate standard deviation of the data; figures in parentheses indicate size of sample (number of sample plots). For practical use, this average value should be regarded as the approximate central value of a site quality class with an approximate range indicated by the standard deviation where this is shown. Where there were not enough plots to calculate a standard deviation the approximate range should be regarded as about plus or minus 10. It is assumed that the average values shown and their approximate ranges apply to all soils within each group even though they were not all sampled.

7/ Raw products of the forest, other than logs, poles, and pulpwood; in this case, principally floral greenery and cascara bark.
Low - Usually submarginal harvest.
Medium - Harvest less than annual interval.
High - Usually good annual harvest.

8/ Brush Encroachment: Slight - No special problem
Moderate - Slows initial growth of Douglas-fir, delays development.
Severe - Immediate and severe competition reduces survival of Douglas-fir.

9/ The relative suitability for producing Christmas trees of salable quality <u>without</u> cultural treatment. The higher sites will often produce better Christmas trees under intensive cultural treatment.
Low - Rapid growth, poor quality, excessive cultural treatment required.
Medium - Moderate cultural treatment required for quality.
High - Quality product without cultural treatment.

10/ Abbreviations of soils are as follows:

c	clay	l	loam	si	silt
co	coarse	r	rocky	st	stony
f	fine	s	sandy	v	very
g	gravelly				

EXHIBIT 2-3. Suitability of soils for wildlife, food and cover in Puget Sound Area

Soils by groups	Suitability of soils for uses cited							Remarks
	Food and cover				Wildlife			
	Trees	Shrubs	Forbs	Cultivated	Deer	Birds	Waterfowl	
Group 1								
Deep, well-drained, and somewhat excessively drained terraces and uplands. Barneston Barneston-Wilkeson Barnhardt Carlsborg Chimacum Cinebar Cispus Corkindale Crescent Dick Ebeys Everett Fitch Giles Gilligan Gravel Pits 2/ Greenwater Grove Hoypus Indianola Keystone Kickerville Klaus Lynden Lystair National Nesika Nisqually Nordby Pondilla Ragnar San Juan Sauk Skykomish Smith Creek Snoqualmie Sol Duc Spanaway Thornwood Tumwater	Douglas-fir	Blackberry, huckleberry, elderberry, and Oregon grape	Bracken fern, sword fern, moss, and twinflower	Pasture, hay, small grain, canefruit, strawberries and vegetables 1/	Good	Quail, grouse, doves, pheasants -- good to excellent	Not suited	1/ Cultivated category applies only on slopes of less than 15% Slopes over 15% are suited for trees, shrubs and forbs. 2/ Gravel pits unsuited for cultivation.
Group 2								
Moderately shallow, somewhat poorly and moderately well-drained upland and terrace soils. Agnew Agnew-Elwha Ahl Alderwood Astoria Bow Bozarth Cagey Casey Cathcart Clallam Cloquallum Colvos Colvos-Kitsap complex Coupeville Coveland Dabob Delphi Discovery Bay Discovery Bay - Rock outcrop complex 3/ Discovery Bay - Hoodsport 3/ Elwha Enumclaw Fidalgo 3/ Hale Harstine Heisler Kapowsin Kitsap Marblemount 3/ Melbourne Olele 3/ Olympic Orting Oso Pickett Prather Quilcene Roche Rockland 3/ Rough broken land 3/ Rough mountainous land, Oso materials 3/ Rough stony land 3/ Rough broken land, Olympic materials 3/ San Juan, moderately deep Saxon Schnorbush Shelton Sequim Sinclair Skiyou Squalicum Steep broken land 3/ Stossel Swantown Tebo Tenino Tokul Townsend Triton Waddell Whatcom Whidbey Wickersham Wilkeson	Douglas-fir, red alder, cedar, hemlock, birch, and big leaf maple -- fairly good.	Salal, Oregon grape, snowberry, thimble-berry, elderberry, blackberry, vine maple, and wild rose -- good.	Bracken fern, sword fern -- good.	Grasses, legumes, small grain, vegetables, and canefruit 1/	Good	Pheasant, quail, grouse -- fair for nesting; fairly good for cover.	Not suited	1/ Cultivated category applies only on slopes of less than 15%. Slopes over 15% are suited for trees, shrubs and forbs. 3/ These soils generally unsuited for cultivation because of stoniness, rock outcrops, shallowness, and/or slope.

Exhibit 2-3 Suitability of soils for wildlife, food and cover in Puget Sound Area **(continued)**

Soils by groups	Suitability of soils for uses cited							Remarks
	Food and cover				Wildlife			
	Trees	Shrubs	Forbs	Cultivated	Deer	Birds	Waterfowl	
Group 3 Shallow and moderately shallow, poorly drained, moderately fine and moderately coarse textured terrace basin soils. Bellingham, Buckley, Cagey-Norma, Clackamas, Clipper, Custer, Edmonds, Everson, Hemmi, Kopiah, McKenna, Norma, Reed, Schooley, Skagit, Thornton, Tromp, Woodlyn	Red alder, cedar, birch, hemlock, Douglas-fir, cottonwood and big leaf maple	Blackberry, ocean spray, snowberry, and wild rose	Bracken fern	Grasses and legumes -- suited for wetlands 4/	Good	Pheasants, quail, grouse -- fairly good for food; poor for nesting.	Undrained soils are fair for nesting; good for food. Drained soils are not suited for nesting; good for food.	4/ Drainage generally required for cultivated uses.
Group 4 Poorly drained and very poorly drained organic soils consisting of peats and mucks. Carbondale, Dupont, Fresh water marsh 6/, Greenwood 6/, Hovde 6/, McMurray, Orcas 6/, Spalding, Tacoma, Tanwax, Tidal Marsh 6/, Tisch	Cedar, hemlock, and lodgepole pine. Tidal marsh cover consists of salt, grasses and shrubs.	Ocean spray and blackberry		Where drained: suited for grasses, legumes and vegetables 5/	Where drained: fairly good for browse. Where undrained: not suited.	Where drained fairly good for food; fair to poor for nesting. Where undrained: fair for food. Not suited for nesting.	Where drained: fairly good for nesting, food and cover. Where undrained: good for food and nesting.	5/ Drainage and water control necessary for cultivated uses. 6/ These soils and land forms unsuited for cultivated uses because of fertility and/or saltiness.
Group 5 Deep and poorly drained and somewhat poorly drained, moderately fine and fine textured bottomland soils subject to flooding. Alluvial soils, undifferentiated, Belfast, Chehalis, Cokedale, Dungeness, Issaquah, Koch, Lummi, Maytown, Nookachamps, Nooksack, Nuby, Puget, Sammamish, Shuwah, Skokomish, Snohomish, Sultan, Sumas, Wapato, Woodinville	Cedar, Douglas-fir, hemlock, red alder,	Blackberry, snowberry, and ocean spray		Grain, grasses, legumes, small grain, and vegetables	Fairly good where drained and protected from flooding.	Pheasants, grouse, quail-poor to not suited for nesting because of periodic flooding. Good for food.	Fair to poor for nesting. Good for food. Poor for nesting during flood periods.	
Group 6 Well drained and somewhat excessively drained, moderately coarse and coarse textured bottomland soils subject to flooding. Camas, Edgewick, Juno, Kline, Neptune, Newberg, Pilchuck, Puyallup, Salal, Coastal Beach 7/, Riverwash 8/	Douglas-fir, big leaf maple, cottonwood, red alder, and vine maple	Blackberry, huckleberry, elderberry, Oregon grape, and snowberry		Grasses, legumes, small grain, canefruit, strawberries corn, vegetables and vegetable seed	Good where protected from floods. Not suited while flooding.	Good for food and cover. Good nesting sites where protected from flooding. Poor nesting sites where unprotected and subject to flooding.	Not suited because soils are droughty. May be suited for nesting except when flooding	7/ Coastal beach unsuited for cultivation. Best suited for game preserve. 8/ Riverwash unsuited for cultivation and crop or wood production because of frequent flooding and requires all possible vegetation for watershed protection

Exhibit 2-4 Determination of Pasture Production.

The basic objective in the formulation of plans is to provide the best use or combination of uses of water and related land resources to meet all perceivable long and short-term needs.

Following the first rush of settlement in any newly settled area, one of the prime determinants for land use is the earning capacity of the land per acre; i.e., land for urban development usually gives a higher return per acre than land used in an agricultural use, and land for industrial or commercial use commands a higher value than does land in the residential areas. As land use is a prime consideration in planning, it is necessary to evaluate returns to land from segments within the use categories. The determination of net income to land is determined through cost return analysis. Advantages and disadvantages of various uses can be determined in this manner Although census data is probably adequate to determine trends in land use within the agricultural industry, the manipulation of the trends through planning is dependent upon income to, or ownership of, land. To determine probabilities of use in agriculture, net return to land must be separated from that of the secondary industry on the farm; i.e., to determine net return to land under dairying, the dairy must be separated from the forage production enterprise in order to make the proper determinations.

The determination of net return to land is doubly important in an area such as the Puget Sound where a wide range of crops may be grown. To understand pressures for land use within the agricultural sector, it is necessary to evaluate the return to land from the various crops or uses to which land may be put within the realm of agriculture. To determine the cost return or the benefits to land from various uses, it is first necessary to segregate the various enterprises on the farm so that the farmer or manager may make proper determinations of the best use to which the land can be put, from the standpoint of dollar returns.

Census data, as it is issued through the Agricultural Census, does not provide an analysis of these figures in such a manner that the returns to land can be determined. Therefore, it became necessary to develop a system of determining yields from pasture lands in order to arrive at the actual net return to the land from its use for forage and pasture production. To analyze this type of situation one must have knowledge of the actual yields returned from pasture and other lands producing forage for the livestock on the operating unit. Inasmuch as the census data does not provide pasture yields, it was therefore necessary to perform an analysis of the livestock industry itself to determine the feed required to feed the numbers of livestock reported by the census within the area.

To determine feed requirements for livestock and poultry from data recorded in the Agricultural Census (1964), the census categories must be disaggregated in line with accepted practices used in the enterprises. (Hogs, sheep, turkeys, etc. were disregarded as being too few to be of consequence.)

The following steps were taken:

I. Determination of dairy cow feed requirements:

A. Ascertain average annual milk production per cow.
   1. Convert milk products to a common unit–pounds.
      a. Milk sold as whole milk is given in pounds.
      b. Convert milk sold by the quart (census) to pounds at the rate of 2 pounds per quart.
      c. Convert butterfat (census) to milk equivalent by the formula: BF divided by 4, times 100 equals pounds.
   2. Add a, b, c, to get total pounds of milk produced.
   3. Average milk production per cow is determined by total pounds of milk divided by the number of cows (census).

B. Determine total digestible nutrients (TDN) required for milk production.
   1. Assume average weight of producing cow to be 1200 pounds.
   2. From "Production vs. TDN" chart, determine the annual TDN's required per cow.
   3. Multiply this by the number of cows (census) to get TDN's required.

II. Calculation of TDN's required for all other classes of cattle and calves:

(Use daily TDN requirements from Morrison's "Feeds and Feeding" by class, weights, and days fed, times numbers in class.)

A. First determine the number of cattle held during the year or part of the year.
   1. This is the sum of all cattle and calves on listed inventory, plus cattle and calves, sold, plus estimated number slaughtered for home use.
      a. From census data (1964 Agricultural Census by County):
         1) Find number of cattle and calves held
         2) Find number of cattle sold
         3) Find number of calves sold
         4) Estimate number of cattle slaughtered for homes use (number of farms reporting livestock times 2)
         5) Find number of cows and heifers that have calved
         6) Find number of milk cows (1 + 2 + 3 + 4 = total number of cattle)
         7) Determine number of beef cows (5 minus 6 = number of beef cows)

B. Compute beef cow TDN's per day by cow numbers at assumed weight of 1,000 pounds.

C. Compute replacement needs for cattle and calves by classes.
   1. Calves needed to replace herd culls:
      a. In the case of the dairy herd, we assume a herd life of approximately six years in the milking string. This requires that approximately 16.666 percent of the herd number be replaced each year by heifers at two years of age. To achieve this, the beginning calves held for replacement must be approximately 1.4 times this number to allow for culling before entry into the milking herd. Culling is done as yearlings and before entry in the milking herd. Cull to 1.1 at yearling stage.
      b. In the case of beef herds, we assume a herd life of approximately seven years. This requires approximately 14.285 percent of the herd number to be replaced annually by heifers two years of age. In the case of beef calves, the beginning number of weaning age should be at least 1.2 times the number needed at two years of age to allow for culling before entry into the breeding herd. Cull to 1.1 at yearling stage.
      c. In the case of bulls needed for dairy herd sires, it is assumed one bull is needed for approximately 50 cows where herd sires are used. Herd sires are assumed to be used in 50 percent of the herds. Artificial insemination is used in the other 50 percent. In order to replace bulls every four years, it is necessary that approximately 0.5 of one percent of cow numbers under a herd sire be ready to go into the herd at two years of age. To achieve this number, the beginning bull calf number will need to be approximately 1.4 times the number needed at two years in order to allow for culling before entry into herd. Cull to 1.1 times the number needed at yearling stage.
      d. In the case of bulls needed for beef herd sires, it is assumed one bull is needed for 25 cows and average use life is estimated at four years. The number of bulls requiring replacement each year is one percent of beef cow numbers. To achieve this number, the beginning calf figure should be approximately 1.2 times the annual herd requirement to allow for periodic culling before bulls are entered into the herd. Cull to 1.1 times the requirements at yearling stage.

D. Determine the number of cattle and calves in other than replacement classes.
   1. Cattle and calves sold:
      a. Cattle sold.
         1) Fat steers (census)
         2) Beef bulls (same as final replacement figure)
         3) Beef cows (same as final replacement figure)

4) Dairy cows (same as final replacement figure)
5) Dairy bulls (same as final replacement figure)
6) Beef heifers (difference between calves kept and cows replaced)
7) Dairy heifers (difference between calves kept and cows replaced)
8) Dairy steers (difference between total of above and census cattle)

b. Calves sold.

1) Beef steers (50 percent of calves, minus death loss of 2 percent, minus replacement bulls)
2) Beef heifers (50 percent of calves, minus death loss of 2 percent, minus replacement needs)
3) dairy calves (total calves sold minus beef steers and heifers; death loss automatically accounted for)

E. Cattle slaughtered.

1. Census number of farms reporting livestock (dairy and beef) times 2.
Note: Cattle total is equal to inventory plus slaughter, as no figure is given for slaughter.

By following the procedures outlined, the total TDN requirements for the composite herd were determined. Census data provided the amounts of hay, grain and silage produced in the area. Data were also available as to tons of hay purchased and hay sold, and the amounts of processed feeds purchased. This then left the unknown quantity of feed produced as pasture and aftermath grazing.

From total requirements, quantities of feeds purchased were subtracted, the remainder being the total grown on the farms. From total produced, hay, silage and grain in TDN's were subtracted; the remainder equaling the total produced from pasture and aftermath grazing. This was divided by acres in this use to get the average yield. The average pasture production for the Puget Sound Area in this analysis is extremely close to the conversion figure of hay production as reported in census data.

III. Calculation of feed used for poultry were made as follows:

(Calculation of feed for poultry were needed in order to balance the total feed inventory.)

A. Determine replacement chickens from census data. From total chickens four months old or over, the numbers of laying hens and pullets, plus one percent for roosters were subtracted. This gave pullet and rooster replacement inventory and was divided by 12 to determine monthly replacements for hens and roosters sold.

B. Feed needs were computed by multiplying the number of replacement poultry per month by 4.166 pounds of feed per month, and times 12 for yearly needs. Broilers were computed at 10 pounds of feed per bird. Feed for adult birds was computed at 120 pounds per year.

Use of the above method resulted in the determination that 451,264,900 pounds of digestible nutrients (TDN) were produced as unharvested forage for an average production per acre of 4.94 CNU's or 2.3 tons of hay equivalent.

The use of cropland for pasture, more than 75 percent in preference to other possible crops, points up a need to establish a value for pasture. Some of the best cropland is used for the production of grasses for livestock grazing, indicating that pasture may be one of its best uses. Using the procedure outlined in this exhibit, it has been proven that the use of cropland for the production of grasses is often competitive with other high-income crops.

EXHIBIT 2-5. Explanation of Calculated Nutritional Unit (CNU)

Puget Sound Production Figures

Land uses in many areas throughout the country indicate that forage production is competitive to so-called cash crops and other land uses, yet we find pastureland is generally assigned a far lower net income. This indicates that a different method than that now in use is necessary for critical analysis. To determine the value of the forage, so produced, to the land on which it is produced requires the single enterprise analysis of the overall farm operation. It should be indicated here that it is possible in the Puget Sound Area to purchase all feeds and produce a profit on the dairy industry separate from that of the values derived from the land in that a 60-cow dairy having a production of approximately 13,500 pounds of milk per cow will produce enough income to pay full price for the forage produced on the farm and still show a profit.

To measure the effective nutrient yield of products harvested by animals or unweighed machine harvest, it is necessary to set up a new unit of measurement. This unit is named "Calculated Nutritional Unit" based on tables in Morrison's "Feeds and Feedings." Feeds are priced to the livestock at the lowest alternate cost of similar TDN (total digestible nutrients) available in the market. This gives gross value from which all production costs are subtracted to obtain net income to land and management.

As an example, farmers in the Puget Sound Area have a wide variety of crops from which to choose for the utilization of land in profit-producing ventures. Among the crops which can be grown in addition to forage are a wide variety of vegetables such as canning peas, beans, broccoli, canning corn, etc.; cane fruits, strawberries, bush fruits, potatoes and small grains such as oats and barley. Even with this wide choice of crops, more than 75 percent of the land is devoted to the raising of forage for livestock, dominantly dairy. Therefore, it is obvious that forage production is returning an acceptable rental in relation to other crops.

Resource planners are frequently confronted with pricing the products of the land. In project and basin planning, where there are numerous competitive uses for land such as farming, wildlife, recreation or urban, it is vital that true incomes be used to aid in proper plan formulation. The situation very often is that of pricing forage used in multi-enterprise farming operations such as forage and beef or forage and milk. When the produce, such as graze or green chop, needs to be evaluated in order to closely estimate net return to the land in dollars, a price must be derived. This price, once derived, is then used in the same manner in project analysis as though it were derived in actual market exchange.

To determine to what extent the segments of a mixed farming operation are self-sustaining, it is common, as in other business, to divide the operation into separate enterprises or departments such as grain, hay, dairy, etc. Although all enterprises are under the same managment, each is operated as a separate entity within the farm or ranch. By using this "single enterprise" approach and farm cost accounting procedures, management can see at a glance the profit or loss position of the individual enterprise and can also determine benefits from programs within the enterprise. The application of farm accounting techniques then becomes a practical tool to aid the farm manager. The agricultural economist will find the same tool a powerful aid in resource planning.

Field experience in evaluating floodwater damages and determining benefits from watershed projects in the Puget Sound Area of Washington has led to the method of analysis presented here.

The common system of using an "Animal Unit Month" in forage computation is not useful in the method here in described for it is a variable term usually applied in studies concerned with management of grass to prevent over-grazing or other grass mismanagement. In such studies the nutrients supplied to stock are secondary considerations to forage management.

For the analysis presented here, a unit of digestible nutrients is used It is call the "Calculated Nutritional Unit" (CNU) and is defined as one-twelfth (1/12th) of the yearly requirement of digestible nutrients fed in a balanced ration to a 1,000-pound beef cow, including the requirement to nurse and feed the calf to eight months of age at a weight of 475 pounds. From calculations shown in Table 1, this is estimated to be 465 pounds of TDN per month. The equivalent is a 1,000-pound dairy cow producing 5,900 pounds of milk.

A graph has been prepared (Figure 1) to show yearly feed requirements in TDN for cows of various

weights producing various quantities of milk. This is used for rapid calculation of feed requirements for the herd.

From contacts with farmers in proposed watershed projects in the State of Washington, it has been found that stockmen are familiar with certain elements of measurement. These are; (a) the amount of milk or beef produced; (b) the number and approximate weight of cows and other stock in the herd; and (c) the tons of hay and milled feed purchased. From this information it is possible to derive a close approximation of the effective harvested forage yields on the farm.

The method proposed for pricing CNU's is composed of two parts or steps which are described as follows:

Step 1. Determination of the effective harvested yield of forage on farms:

Divide the number of pounds of milk produced by the number of cows milked (including those temporarily dry). This gives the average production per cow. Average milk production is plotted against TDN required per cow relative to cow weight (Table 1). Multiply by herd numbers to get TDN required for this portion of livestock.

To this, add TDN required for young stock by weight; i.e., a 600-pound hiefer is approximately 0.6 of a calculated nutritional unit and is so computed for the time she has been in the herd during the year. Bulls and other stock fed forage from the farm are included and all needed TDN totaled to get feed requirements for production records.

Next, the amount of feed purchased, both hay and grain, is converted to TDN. Subtract this from total requirements and the remainder will be TDN's harvested on the farm. Divide by 465 (TDN in CNU) to get CNU's and divide again by acres to get harvested yield in CNU's per acre.

Caution should be exercised to make sure that the herd is receiving balanced rations. If production is so low that it is obvious more tons of material were taken than is indicated by this method of analysis, ration imbalance or inadequate feeding is indicated.

Example: 100 head of 1,000-pound cows with calves on 1,200 acres of pasture.

From Table 1, it is determined that each cow needs 5,580 TDN yearly to produce a 475-pound calf. Therefore, it takes 11.76 TDN per pound of beef produced as a calf (5,580 divided by 475).

Total herd needs become 558,000 TDN (5,580 x 100).

If at the end of the year the cows weigh only 900 pounds and the calves come off at 350 pounds, the beef produced from calves would be 35,000 pounds, minus a loss on cows of 10,000 pounds, or a net beef production of 25,000. From above standard 11.76 TDN per pound, it is found the pasture produced 294,000 pounds TDN (25,000 x 11.76). CNU's effectively harvested from pasture then is 294,000 divided by 465 TDN or 632.25.

This analysis, then, serves to point out to the rancher a need for better management or better nutritional balance.

Step 2. Pricing:

Cost accounting is needed on the multi-enterprise farms to furnish guidance to management in evaluating each enterprise or program within an enterprise. Management will separate the overall farming operation into single enterprise units. These units might be, but are not limited to, such crops as grain, forage, dairy, beef, saddle horses, etc. Setting the various enterprises up as single units enables management to determine costs and revenues of each. By this method, if the livestock enterprise uses corn from the grain enterprise, the market price of the corn is charged to the livestock and credited to the grain in the farm account books.

By converting forage and concentrates to TDN, a common denominator of comparison for feeding purposes is provided. By this conversion, one ton of hay equals 1,000 TDN; one ton of grass silage equals 333 TDN; one ton of green chop equals 320 TDN; and one ton of grain equals 1,500 TDN.

The above conversion is adaptable to local feed data where information is available. The herdsman or manager computes TDN cost and makes decisions accordingly.

The TDN as the common denominator then becomes useful in pricing the feed forms such as silage, green chop or graze which are not commonly priced in actual market exchange.

Since the individual's cost of production is not a significant factor in the overall market price, he need not consider it in pricing the feed forms from one enterprise to another on his farm. In the absence of a posted market, he will price the units at the lowest alternate cost of available equivalent units of digestible nutrients. The dairy enterprise, to be self-sustaining, thus must be charged the market price for the TDN's it requires.

A pound of digestible nutrients in the form of milled concentrates costs the farmer $.043 per

pound. (Milled concentrates contain approximately 1,500 pounds of digestible nutrients to the ton and the adjusted normalized per ton price is $65. Sixty-five dollars divided by 1,500 equals $.043 per pound.)

A pound of digestible nutrients from hay costs the farmer $.033 per pound. (Good quality hay contains an average of 1,000 pounds of digestible nutrients per ton and the cost is $33 per ton, ANP. Thirty-three dollars divided by 1,000 equals $.033 per pound.) If similar quality hay is available at $25 per ton ANP, the pound of digestible nutrients would cost $.025.

Common business practice will indicate to the farmer that for the non-market items of grazed forage or green chop he will price those items to the enterprise using them (in this case, the dairy) at the price of the lowest cost alternative available in the market. In this case, grazed forage or green chop used by the dairy enterprise would be charged to the dairy at $.025. A CNU would be priced at $11.62 (465 TDN x $.025).

If the hay price is $33 per ton, the CNU price would be $15.34 (465 x $.033). If, as in the central portion of Washington State, hay is $20 per ton, the price of a CNU would be 465 x $.02 or $9.30.

Once the value of the forage is determined, it is a simple standard procedure to make a cost returns analyses and determine the return to land from the forage or material produced therefrom.

The initial high value placed on land for industrial or commercial use so far exceeds its highest value for use in farming that no use as farm cropland is competitive. The value of cropland for farming is often competitive with its value for housing. Further economic analysis may point out a closer ratio of comparability between agriculture and industry. The use of land for farming through perpetuity and the retention of the farming industry in an area may offset the benefits derived from the gain of a less permanent industry. Since the Puget Sound is a deficit food-producing area, each removal of farmland from agricultural use results in the displaced food being imported from other areas or being produced on lands at a higher unit cost, thus reducing the total farm industry of the area.

TABLE 1. Calculated Nutritional Unit (CNU).

Calculation of Total Digestible Nutrient (TDN) requirements of 1,000-pound beef cow (with calf at side to weight of 475 lbs. at 8 months of age):[1]

Beef Cow Needs (Weight 1,000 lbs.)	TDN/Day	No. Days	Total
Pregnancy	10.5	125	1,312
Nursing calf first four months	13.5	120	1,620
Nursing calf second four months	13.0	120	1,560
Subtotal			4,492
Add 5 percent for waste			225
Total for cow			4,717
Add calf needs beyond those supplied by milk (see below)			861
Total Digestible Nutrients (TDN) per year			5,578
CNU month, 1/12 of 5,578, or			465

Calculation of TDN Needs of Calf

Month	Range in Weight (TDN)	Daily Needs[1] (TDN)	Supplied by Milk (TDN)	Other Needs (TDN)	No. Days	Total Need Other Feeds (TDN)
1	75-125	2.2	1.6	.6	30	18
2	125-175	3.2	1.6	1.6	30	48
3	175-225	4.4	1.6	2.8	30	84
4	225-275	5.0	1.6	3.4	30	102
5	275-325	5.7	1.6	4.1	30	123
6	325-375	6.4	1.6	4.8	30	144
7	375-425	7.0	1.6	5.4	30	162
8	425-475	7.6	1.6	6.0	30	180
						861

Beef cow is expected to furnish 2,400 lbs. of milk or 10 lbs. per day, on the average, for 8 months.[2]

Dairy Cow, (Weight 1,000 lbs., 4% FCM)	TDN/Day	No. Day	Total
Maintenance	7.9	365	2,883
Pregnancy	6.0	90	540
Add for milk production to obtain equivalent of 5,910 lbs. @ .32 TDN per lb.			1,891
Subtotal			5,314
Add 5 percent for waste			266
Total Digestible Nutrients (TDN)			5,580
CNU month, 1/12 of 5,580 or			465

Calculation if cow produces 10,000 lbs. milk	Total
Add: 10,000 - 5,910 = 4,090 x .32 = 1,309	1,309
Subtotal	6,889
Add 5 percent for waste	65
Total Digestible Nutrients (TDN) for 10,000 lbs.	6,954

[1] Morrison's "Feeds and Feeding, 22nd Edition," calculated from Appendix Table III, pages 1087-1088.

[2] Morrison's "Feeds and Feeding, 22nd Edition," from page 737.

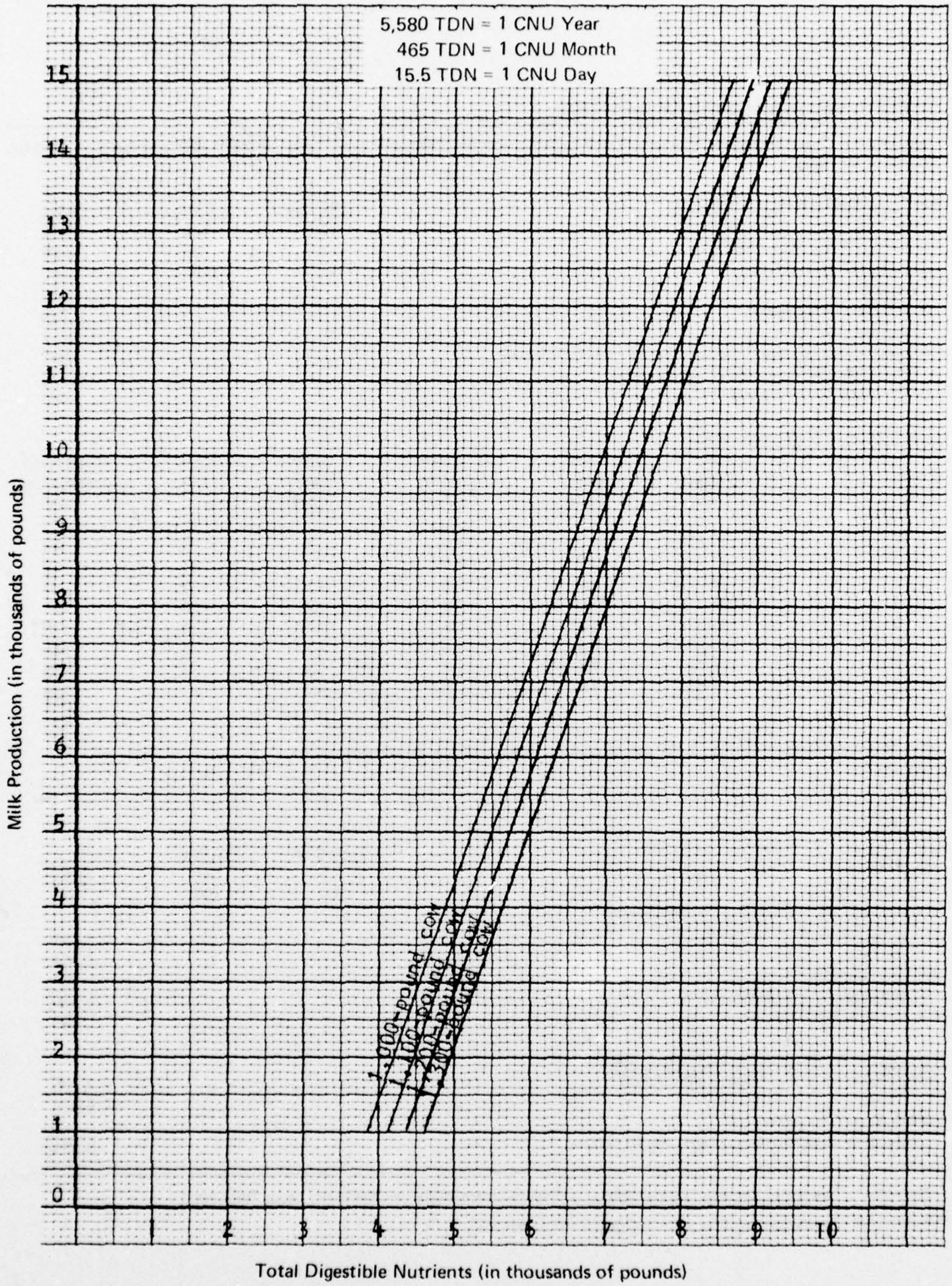


FIGURE 1. Total digestible nutrients required at variable production levels for 1,000-pound, 1,100-pound, 1,200-pound, and 1,300-pound cows

Exhibit 2-6 Costs of Production and Net Income For Selected Yields Per Acre of Pasture Undrained and Drained Puget Sound Area.

Operation	Cost Per Acre Undrained (dollars)	Cost Per Acre Drained (dollars)
Cost of Establishment:		
Plow (2/3 acres per hour)	5.98	5.98
Dics 3 times	7.14	7.14
Roll or Pack	1.33	1.33
Seeding (Drill)	2.78	2.78
Seed Cost	8.00	8.00
Fertilizer	4.00	4.00
Fertilize	1.48	1.48
Clipping	2.58	2.58
Fence	1.50	1.50
Drainage		14.21
Taxes and Assessments	11.00	14.00
Insurance (Liability)	.30	.30
Incidental Expense (Pickup, etc.)	3.00	3.00
Subtotal	49.09	66.30
Value of First Year Grazing (2 CNU's @ $15.35)	30.70	30.70
Net Cost of Establishment	18.39	35.60
	Undrained 7 CNU	Drained 10 CNU
Annual Costs Ersuing Years:		
Stand Amortization (7 yrs. @ 5%)	3.18	6.15
Fertilize	1.48	2.96
Fertilizer (20-9-6 @ $108 per ton)	8.10	13.50
Clipping	2.30	4.60
Spread Droppings	1.50	3.00
Fence	1.20	1.20
Drainage		14.21
Taxes and Assessment + O&M	11.00	14.00
Insurance (Liability)	.30	.30
Incidental Expense	1.00	2.00
Total Annual Costs	30.06	61.92
Costs Converted to Adjusted Normalized Prices (Factor .94)	28.25	58.20
Gross Value of Pasture(@ $15.35 per CNU)	107.45	153.50
Less Annual Costs	28.25	58.20
Net Income	79.20	95.30

Average Net Benefit from Drainage - $16.10.

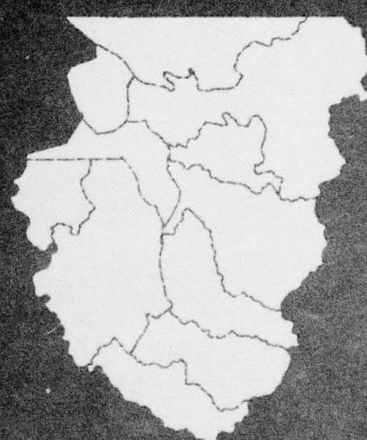
Exhibit 2-7 Costs of Production and Net Income For Selected Yields Per Acre of Pasture Drained and Irrigated Puget Sound Area

Operation	Cost Per Acre Drained (dollars)	Cost Per Acre Irrigated (dollars)
Net Cost of Establishment[1]	35.60	35.60
Annual Costs Ensuing Years:		
Stand Amortization $35.60 (7 yrs. @ 5%)	6.15	6.15
Fertilize	2.96	4.44
Fertilizer	13.50	16.20
Clipping	4.60	4.60
Spread Droppings	3.00	3.00
Fence	1.20	1.20
Drainage	14.21	14.21
Taxes and Assessments	14.00	14.00
Insurance (Liability)	.30	.30
Incidental Expense	2.00	2.00
Subtotal	61.92	66.10
Irrigation:		
System Cost ($200 amortized 20 yrs. @ 6%)		17.45
Repair and Operation		4.00
Labor of Moving Pipe, 4 Irrigations		4.00
Subtotal		25.45
Annual Costs	61.92	91.55
Total Annual Costs Converted to Adjusted Normalized Prices (Factor .94)	58.20	86.05
Gross Value of Pasture (@ $15.35 per CNU)	153.50	199.55
Less Annual Costs	58.20	95.30
Net Income	95.30	104.25

Average Net Benefit Per Acre from Irrigation - $9.05.

[1] From Exhibit 6.

Part Three
Forests - Puget Sound Area



PART THREE—FORESTS
PUGET SOUND AREA

PURPOSE

The purpose of the Forest Chapter is to provide the Puget Sound and Adjacent Waters Study with an inventory of the resource and a status of the industry at planning levels of 1980, 2000 and 2020. An industrial economic analysis, combined with a determination of the hydrologic effects of the growing and harvesting of timber is deemed essential to this purpose. It is further intended to provide such information as may be required in the study of other related subjects.

BASIC ASSUMPTIONS

That the term "Forest Industry" as used herein applies to the harvesting, processing and marketing of timber and forest products.

That forest management programs and forest-based industries will continue to be important facets in the economy of the Puget Sound Area.

That forest resource development will not remain static and that levels of production from managed lands and utilization on all properties will increase.

That the area devoted to the growing of forest products will decrease through conversion to other land uses, such as urban expansion, industrialization, recreation development, etc.

Modern forestry can be defined as the scientific management of forest lands for the continuous production of goods and services. As such, it should not be assumed that timber is the only product of such management. To avoid areas of duplication, however, this Chapter deals only with that part of forestry which specializes in wood fiber production. Other aspects of forest management, such as recreation, fish and wildlife or water are developed in other appendices which deal specifically with those resources or activities.

RELATIONSHIP TO WATER

The role of related land has been recognized as vital to any comprehensive water resource planning mission. The Interdepartmental Staff Committee of the Water Resources Council defines related land as being:

> "That land on which present or projected use and management practices may cause significant effects on the runoff or quantity or quality of the water resource to which it relates, and that land, the use and management of which is significantly affected by or depends upon the existing or proposed measures for the management, development, or use of the water resource to which it relates."

The significance of this statement is readily apparent. Land, as the source and conductor of waters, has a direct bearing on the rate of runoff and the introduction of pollutants. Related land, then, includes not only potential service or benefit areas, it includes all lands within the hydrologic boundaries of the basin.

Within this concept, forest lands are a major concern to the Puget Sound and Adjacent Waters Study. Forest lands make up the major part of the study area and are the source of over 80% of the total water supply. The type of management practiced on these lands has a direct bearing on the quantity and quality of surface waters. Continued urban and industrial expansion in the Puget Sound Area depends, to a large degree upon the proper use and management of forest areas.

The forest products industry is an important segment of the area's economy, second only to aerospace in total input. The continued well being of the industry depends on the maintenance of favorable economic conditions including adequate raw material supplies, water supplies and transportation facilities. The pulp and paper industry particularly, is dependent upon the availability of pure, high-quality water. This industry alone utilizes some 275 million gallons daily in the Puget Sound Area.

Forests and forest-based industries are, therefore, vital segments of comprehensive water resource planning. This appendix has attempted to evaluate these segments and their relation to other activities of the Puget Sound Area.

FOREST LANDS

The forests of the Puget Sound Area range from sea level to the alpine reaches of the Olympic and Cascade Mountains. This wide range of elevation, coupled with like variation of topography, temperature, and precipitation, results in a great variety of tree species and other forms of vegetation. The lower and mid-elevations of the Area contain some of the most productive timberland in the Nation which are, in fact, notable among forest lands the world over. Some of the finest quality timber ever produced originated in the Puget Sound Area of Washington State. Generally, the productive capacity of the stands decreases with altitude, culminating with the picturesque, but noncommercial stands of the alpine areas.

The area lies within the Douglas-fir Subregion, named for the Nation's number one lumber and plywood species–the Douglas-fir. Below 3,500 feet elevation, Douglas-fir predominates, usually characterized by dense, high-volume stands. Average volume per acre is 55 to 65 thousand board feet, ranging to upwards of 135 thousand board feet as a maximum. Also found in pure stands, or in mixture with Douglas-fir, are western hemlock, western redcedar, Pacific silver fir, red alder, big leaf maple and black cottonwood. Above 3,500 feet elevation, there is a gradual transition to stands containing primarily mountain hemlock and true firs. Generally, these stands do not contain high volumes, however, 40 thousand board feet per acre is not uncommon.

Timber stands are usually even-aged, except where partial cutting has occurred. This condition is due in part to past forest fires and to early day logging activities where large areas were denuded of cover at one time. In addition, Douglas-fir and certain other species do not regenerate readily within an existing stand, thus tending to maintain the even-aged status.

The Puget Sound Area supports a large, diversified, forest products industry of importance both locally and Nationally. Virtually all of the softwood products required by the local economy originate from plants within the study area, yet the relationship of the industry to National demand is even more significant. In 1963, it was estimated that 4% of the softwood lumber, 12% of the softwood plywood and 5% of the wood pulp consumed in the Nation originated from plants within the Puget Sound Area. In addition to the major products listed above, the Area's plants produce a large variety of specialized products, including dimension timbers, poles, piling, hardboard and particleboard, shingles and shakes, furniture stock, and the like. Hardwood processing plants are of relatively small importance at the present time, although this segment of the industry is growing.

BACKGROUND AND HISTORY

When the white man migrated westward, he did so in search of land, however, those who came to the Puget Sound Area were initially drawn there because of the forests. They found that the shores of the Sound were lined with tall, virgin timber of the highest quality. The proximity of this type of timber to tidewater answered the need for piling and ship spars in the development elsewhere on the west coast. As a result, logging operations were soon under way.

The first lumber mill, owned by the Puget Sound Milling Company, was set up in 1846, with the first shipment of lumber being made on the Hudson Bay Company steamer "Beaver" in 1848. Also in 1848, the brig "Orbit" out of San Francisco penetrated as far as Budd Inlet (Olympia-Tumwater) to load piling. For this, and similar shipments, the shipper was paying eight cents a lineal foot for piling delivered alongside the vessel.

Puget Sound soon started attracting ships which might have entered other west coast ports for lumber cargoes. An early paper stated, "Every vessel can save from five to six hundred dollars in pilotage and towing by coming to the Puget Sound after their cargoes, instead of the Columbia River". The Coast Survey of 1855 listed sixteen sawmills on Puget Sound with a total output of 85 thousand board feet of lumber per day. One of the largest mills of that era was producing eight thousand board feet of lumber in twelve hours. By 1855, shipments were going to many points along the west coast and to world markets as well, including South America.

The Port Gamble mill, in 1858, was the greatest lumber manufacturing plant on Puget Sound. In a 24-hour period, the mill could produce 50 thousand board feet of lumber in addition to lath, singles and pickets. Numerous other plants sprang up throughout the Puget Sound Area as the demand for lumber continued to increase.

By 1860, cutting operations along the shores of Puget Sound were becoming widespread, although most cutting was done within one or two miles of the shoreline. Although a minor irritant at the time, the methods used by the lumbermen were highly wasteful. The only trees cut were those yielding at least three 24-foot logs with a minimum diameter of 30 inches. Anything not meeting these specifications was left on the ground. In addition, cutting was often done twelve or more feet above the ground, resulting in a "forest" of high stumps. The remnants of these stumps can still be seen throughout the lowland areas.

Thousands of acres of government land, including some of the finest timber, were open to any buyer for $1.25 per acre, however, the formality of buying the land to obtain timber rights was largely ignored. Many of the early loggers believed that government land was free, so they cut any timber that looked desirable, virtually at will. The government tried to prevent such trespass (spoilation) by imposing a charge of $2.50 per thousand board feet of timber cut on public land, however, ownership of the logs was usually difficult to prove. This method was also opposed by the local millmen. President Grant, in an attempt to stop further depredations, sent a special agent whose purpose was to restrain the millmen. He met with only partial success. President Hayes did likewise with much the same result. His agent reported that at least 40 million dollars of spoilage had occurred since 1855 and charged certain mills with the continued cutting of government timber. Despite such wanton plunder, the supply of timber in the Puget Sound Area seemed inexhaustible. So vast did the forests seem in 1870 that one prominent pioneer was quoted as saying, "The supply of logs for lumber will only be exhausted when the mountains and the valleys, surrounding the Sound are destroyed by some great calamity of nature". During this era, some mills logged their own land. Others purchased logs from companies engaged only in logging operations. Some loggers purchased land for the purpose of logging it; some purchased only the standing timber; and others simply pirated the timber without consulting the owner. When purchased, the price of logs ranged from $4 to $10 per thousand board feet for some of the best timber ever produced on this continent.

As the twentieth century approached, independent logging companies gave way to mill ownership and to companies working directly with the mills. A series of depressions during this period provided the impetus for much of this consolidation. The price of lumber fluctuated greatly, but the cut steadily increased due to the number of mills, their increased productive capacity and to the desire of the settlers to clear the land.

In the era before World War I, the principal disposition of the public lands was completed. The National Forests were created and the private timber domains of the region were founded. Timber output rose steadily, but cutting was still mostly along the waterways with the bulk of the forests being held for future values.

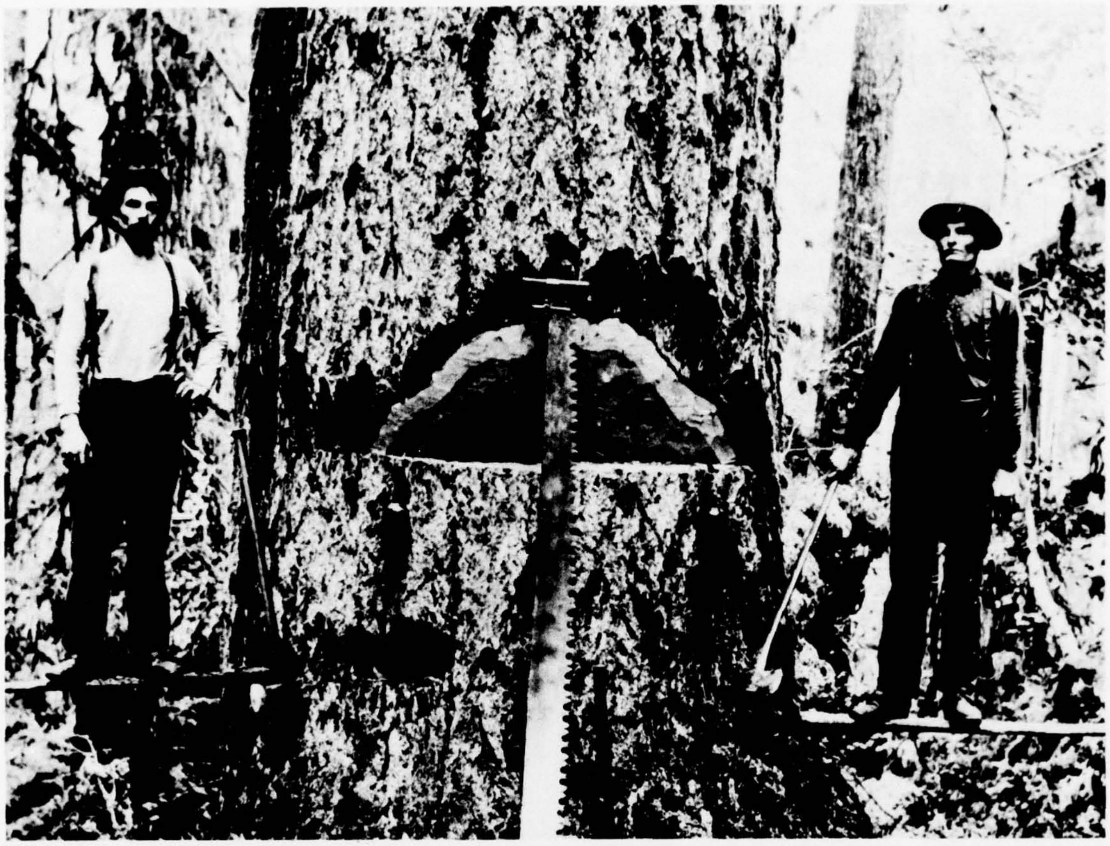


PHOTO 3-1. Early day fallers at work. Photo taken about 1890 in the vicinity of Shelton. (Source unknown)

This era saw the region's first substantial development in forestry practice, the beginning of widespread forest fire control. Shocked by the great Yacolt Fire of 1902 in southern Washington and by other disastrous fires, landowners banded to form protective associations. Establishment of the National Forests brought fire control to these lands. The State government strengthened its laws to promote protection. It was also at this time that schools of forestry were started in several west coast colleges, including the University of Washington.

Following World War I, cutting continued at a high rate, paced by the rising prominence of the plywood industry. The shift of the Nation's forest products industry to the west was furthered by the opening of the Panama Canal and by the growth of export markets. During this period, much of the readily available private holdings were cut and the focal point of the industry shifted to southwest Washington and the Columbia River district. Wood product prices generally declined during the inter-war era, punctuated by sharp market crises following 1920 and 1929. "Overproduction" was the cry of the times, growing more shrill and despairing as the era wore on into the decade of the Great Depression. Private owners liquidated wide stretches of standing timber and abandoned much land.

From its gravest difficulties, the industry harvested some notable gains for forestry. Out of the price and production problems of the depression came Article X of the National Recovery Administration lumber code, which though short-lived, started some industrial landowners on voluntary conservative programs of timber cutting and culture. Various State and Federal legislation enacted during this period helped strengthen the attack on these problems. To

fight overproduction, industry spokesmen advocated sustained yield, which might prove equally instrumental in keeping output up over the long term as in keeping it down over the short term. Efforts to reduce the scale of operations and to cut costs led to changes in operations and to shifts toward truck transportation, which in turn, fostered a reduction in the size of cutting areas and a start toward the development of road networks. Both of these changes helped intensify timber management. Out of the melee of timber liquidation and land abandonment came a strengthening of forest ownership throughout the Area. Many surviving private firms, notably some of the big ones, made plans for retaining, restocking and managing their cutovers.

The large demand for timber products brought about by World War II helped lift the industry out of the economic doldrums. The continued economic prosperity enjoyed by the industry following the war, coupled with the timber management developments that arose during the inter-war years, provided the basis for the intensive management programs and diversified industrial developments of today.

PRESENT STATUS

This section presents information on forest lands and enterprises as they occur within the Puget Sound Area. For the most part, data directly applicable to the study area were not available, as such compilations are normally made on the basis of State, county, or ownership boundaries. It was, therefore, necessary to adjust to the available data to achieve conformity to the study area. As a result, information on forest areas, and ownerships may not be precisely accurate, but is considered a reliable estimate for planning purposes.

The soil-plant-water aspects discussed in this section are general in nature. These are intended to show the relationship of forests to water production and apply equally well throughout the Puget Sound Area. For information on specific areas, refer to the sections devoted to basin analysis.

FOREST LAND MANAGEMENT

Forest Distribution, Character and Composition

The forests of the Puget Sound Area are located throughout all sections of the study area. The wide variations in climate and topography found in the region result in an equally wide variation in the ecological formation of the forest lands. In order to objectively assess the value of these stands for production of timber, water, and other products or services, a common basis is needed for the establishment of primary values. This committee has chosen a criteria which recognizes certain unique physical characteristics which tend to set a given area apart from other similar areas. The resulting classifications, or zones, are, therefore, based primarily on the physical character of the land.

Woodland and Woodlots. This zone includes the many small ownerships scattered throughout the developed area adjacent to Puget Sound and the inland valleys. Historically a part of the principal forest, this zone differs primarily in size of ownership, management practice, and past logging history. Much of the land has been cleared for agricultural, urban, residential, or industrial purposes, particularly along the eastern and southern shores of Puget Sound. The remaining forest stands are situated on lands less compatible for such uses and now occupy under 50% of the total area. This zone was largely cut-over during the early development of the Puget

PHOTO 3-2. The farm woodlot forest–Puyallup Valley. (U.S.F.S. photo).

Sound Area. During this period, forest management for sustained yield was largely unprofitable, so the land was allowed to restock by natural succession. The resulting second-growth stands range up to small sawtimber in size and are composed mainly of western hemlock, western red-cedar, Douglas-fir, red alder, black cottonwood, big leaf maple and associated small hardwood species.

Hydrologically, this zone is of limited concern. Streams are generally small serving as feeders to the lower reaches of the main rivers, or flowing directly into salt water. Precipitation is moderate, topography is gentle to moderate, soils are usually deep and stable. The primary watershed objectives include the protection of stream courses and the prevention of sheet erosion during logging or other forest use.

Principal Forest. This zone extends upwards from the lowlands along the foothills and spur ridges of the Cascade and Olympic Mountains. Elevation range is primarily between 500 to 4,000 feet. The zone contains the bulk of the Area's commercial timberland and is the source of over 80% of the annual harvest. Timber production is the major single use.

Holdings within the zone are varied, but are primarily in Federal, State and large corporate ownerships. As a result, the land is largely under management for timber production purposes. While considerable cutting has occurred throughout the area, large blocks of uncut, old-growth timber remain, particularly in the less accessible upper reaches of the zone. The most common species are Douglas-fir, western hemlock, and western red-cedar. Several other softwood and hardwood species occur sporadically throughout the area.

PHOTO 3-3. The principal forest–Snohomish Basin. (U.S.F.S. photo).

PHOTO 3-4. The upper forest–Skagit Basin. (State of Washington photo).

Hydrologically, the zone is of high importance. Precipitation, while moderate in some areas, exceeds 180 inches per year in portions of the Cascade and southern Olympic Mountains, with moderate snowpacks at higher elevations. Topography is generally steep and rugged with much evidence of glacial activity. Soils are generally thin, primarily of volcanic and glacial origin, and in some locations are highly unstable. The primary watershed objectives during timber harvest, or other forest use, include the protection of stream courses, the protection of the soil mantle, the stabilization of disturbed areas and the re-establishment of a protective plant cover.

Upper Forest. This zone occurs immediately above the principal forest and extends nearly to timberline, usually between 3,000 to 6,000 feet elevation. It differs from the Principal Forest Zone chiefly in species composition, slower growth, poorer tree form and a more scattered nature of the stands. As a consequence, this zone is of lesser importance for timber production, but is valuable for other uses, particularly outdoor recreation.

Land ownership within the zone is primarily Federal, although large blocks of private timberland occur in the Snohomish, Cedar-Green, and Puyallup Basins. Cutting has occurred sporadically throughout the zone, however, the bulk of the land remains in old-growth timber. True fir-mountain hemlock stands predominate on the area, intermingled with lodgepole pine, Englemann spruce and other high-elevation species.

Hydrologically, the zone is quite similar to the principal forest. Precipitation is generally heavy, much of which is in the form of snow, resulting in moderate to heavy winter snowpacks. These snowpacks are of primary importance in maintaining summer streamflows. Soils are thin, generally coarse in texture and highly erosive. The primary watershed objectives are similar to those of the principal forest zone, but require greater precautionary measures. The protection of the soil mantle and the stabilization of disturbed areas, particularly, are of paramount importance. The preservation or re-establishment of the vegetative cover assumes greater importance for this reason.

Subalpine Forest. This zone occurs immediately above the Upper Forest and extends nearly to the crest of the major mountain ranges. The area contains some of the Nation's most outstanding mountain scenery, being characterized by cirque lakes, alpine meadows, and numerous glaciers. Forest stands occur only as small, scattered, usually stunted clumps of timber. The land is primarily valuable for outdoor recreation and water retention through winter snowpacks. While some cutting may have occurred in land use conversion, i.e., ski area developments, etc., the zone has no commercial importance for timber production.

PHOTO 3-5. The subalpine forest–Nooksack Basin (U.S.F.S. photo).

Land ownership within this zone is almost entirely Federal, primarily in National Forests and National Parks. The bulk of the land is held in limited use status, being included within primitive areas, wilderness areas, or National Parks.

The zone is almost identical to the Upper Forest in hydrologic importance. Soils, however, range from very thin to non-existent. Since commercial developments are limited in this zone, the major watershed objective is the maintenance of existing conditions.

Forest Land Ownership and Management Programs

National Forests. National Forest lands include approximately 2,244,000 acres, roughly 26% of the total land area under study. Of the forest land, 35% of the total forest area and 26% of the commercial forest area is under National forest jurisdiction. Forest Service lands are located in the higher elevations of all hydrologic study units, excepting only the San Juan and Whidbey-Camano Islands. Hydrologically, the National Forests are of prime importance. Most of the Area's major rivers and many of the smaller streams originate on National Forest land.

The Forest Service is bound by law to manage the National Forests under multiple-use, sustained-yield principles. The basic aim of this form of management is to create a coordinated combination of uses that results in a greater benefit to the general public than would be the sum of the individual uncoordinated uses. The law directs that the renewable resources, including timber, range, outdoor recreation, watershed, fish and wildlife, be given equal planning consideration. It is recognized, however, that values may vary from one area to another and that the uses planned need not necessarily be in the combination that gives the greatest dollar return or the greatest product output. Certain forest uses do not lend themselves to strict evaluation in such terms. In the implementation of this policy, the Forest Service requires the preparation of multiple-use plans for each administrative unit. Within this framework, specific management plans for each of the separate resources or activities are formulated.

Timber production is an integral part of multiple-use management, being the primary objective in some instances and secondary where other uses are paramount. The sustained-yield concept, as applied to timber, requires that the rate of harvesting be no greater than the rate of growth. This objective is controlled through recurrent evaluation of the timber resource. An inventory is made at periodic intervals, normally every ten years. Basic data, including volume, rate of growth, mortality and the like, is obtained from a survey of permanent plots established for this purpose. This data is analyzed in conjunction with other factors, including market trends, utilization standards and advances in technology. The result is the basis for establishing the harvesting budgets for each administrative unit. Such a harvesting program, combined with associated programs in reforestation, timber stand improvement and protection, tends to insure an even flow of timber from National Forest lands.

Early timber cutting in the Puget Sound Area was concentrated on private lands with only limited cutting of National Forest timber in the lower accessible areas. Timber harvesting in the higher elevations has progressively increased with developing access and timber demand. Cutting is now approaching the allowable limits consistent with sustained-yield principles. The bulk of the timberland remains in uncut, old-growth status. These stands contain some 51% of the Area's sawtimber volume. The old-growth stands are being harvested, as access and cutting schedules permit, with the aim of creating a regulated series of stand-size classes, thus more fully utilizing the growth potential of the land. Such regulation is not expected, however, for several decades. As a result of this objective, cut-over lands are restocked as soon as practicable for the continuance of timber production and for other purposes including the protection of watershed values.

Other Federal Lands. Federally owned lands, exclusive of the National Forests, comprise nearly 1,246,000 acres in the Puget Sound Area. Of this, 55% or some 683,000 acres is classified as forest land. Further classification of forest lands by agency indicates:

Agency	Total Land (acres)	Forest Land (acres)
Department of the Interior		
National Park Service	1,083,300	581,090
Bureau of Indian Affairs*	30,350	24,810
Department of Defense		
Army	90,210	57,990
Navy	27,660	14,140
Air Force	5,260	1,270
Miscellaneous	9,000	3,990
TOTAL	1,245,780	683,290

* Includes tribal and other Indian owned lands within the boundaries of established reservations administered by the Bureau of Indian Affairs.

Of the total forest land, 39% or 267,580 acres is non-commercial forest; 38% or 262,890 acres is productive land reserved for purposes other than timber production. The remaining 152,820 acres is classified as commercial forest land.

The largest block of land under this classification is held by the National Park Service within the Mt. Rainier, Olympic and North Cascades National Parks and the Ross Lake National Recreation Area. These lands are managed for public outdoor recreation which emphasizes the preservation of native flora and fauna. While the land is not available for timber production, the Park Service maintains fire suppression and other work programs necessary in meeting their management objectives. As a result, water production and erosion are controlled through the preservation of the natural hydrologic cycle. Hydrologically, National Park lands are of prime importance, as several of the Area's major rivers and many smaller streams originate on National Park lands.

The second largest block of land is under the jurisdiction of the Department of Defense. These lands are held primarily for purposes of National defense, however, the forest areas are managed for the production of timber where such use does not interfere with the primary purpose. Most of these lands have been placed under intensive forest management during the last decade with the primary goals being reforestation and the improvement of existing timber stands. Hydrologically, these lands are of limited importance since they are largely located in the lowland areas.

The third largest block of land is administered by the Bureau of Indian Affairs and includes all land with the boundaries of established Indian reservations. The BIA is encouraging the acceptance of multiple-use, sustained-yield principles on these lands and has had notable success with certain Indian people. These lands were largely cut-over during the past century and are now undergoing reforestation and improvement by second-growth stands. Indian lands are situated on or near the shoreline of Puget Sound and are of limited hydrologic importance.

Other Federal lands occur as small scattered tracts held by several agencies, notably, the Bureau of Land Management, Bureau of Sport Fisheries and Wildlife, Bonneville Power Administration and the Department of Justice. These lands have no significant effect on either timber or water production at the present time.

State of Washington Lands. The State Department of Natural Resources is the third largest landholder in the Puget Sound Area. The Department administers all resource activities on 609,000 acres, which is some 7% of the total study area. Three hundred and forty-three thousand acres of this is County Trust Land managed under sustained-yield principles for the counties concerned. Six percent of the total sawtimber volume in the Area is under Department jurisdiction. This State managed timberland is found in all of the hydrologic study units. Most larger blocks of timber are located in the lower elevations of the principal Forest Zone, although some extend into the lower reaches of the Upper Forest Zone. Scattered State holdings occur within the Woodland and Woodlot Zone. State owned lands in the Subalpine Forest Zone occur mainly in the Sultan River Basin.

State owned lands are important to the hydrologic complex of the Puget Sound Area. Many of the main stem access roads to large private or National Forest holdings follow the major rivers crossing State land. A great many side streams entering these rivers originate on or cross State land.

The State Department of Natural Resources is directed by statute to manage State owned lands for the highest income to the State trust funds. The program is conducted under a sustained-yield system with all the principles of multiple-use management. The following table indicates the six benefitting trust funds on a state-wide basis. No breakdown specifically applicable to the Puget Sound Area is available.

Common Schools -	1,813,546 acres
Washington State University -	152,996 acres
and Normal Schools -	69,626 acres
University of Washington -	86,838 acres
Department of Institutions -	81,839 acres
Capitol Building -	111,723 acres
Forest Board—Fee and	
County Trust -	626,050 acres

Timber sales bring in 60 to 70% of the total revenue to the Department. Another 10 to 12% of the income is received from leases and rentals. In addition, income is derived from sales and leases of tide, shore and harbor lands.

The program is directed by the Commissioner of Public lands with a technical staff operated through a Supervisor equivalent to the older title, State Forester. Broad policy is established by the

State Board of Natural Resources, consisting of the Governor of the State of Washington, Superintendent of Public Instruction, Land Commissioner, Dean of the College of Forest Resources of the University of Washington, and the Director of Agricultural Sciences of Washington State University.

The Supervisor directs the Department through nine divisions, each headed by an Assistant Supervisor. The State has been divided into six supervisory areas, each of which is administered by an Area Field Supervisor. The supervisory areas contain 23 Districts, each supervised by a District Administrator.

The general policies of the Department are based on the Forest Practices Act of January 1, 1946. The act stipulates that State owned timberlands are to be kept productive by maintenance of continuous growth of timber on all lands suitable for such purposes. A great portion of these lands were cut-over during the "glory days of logging" in the late 1890's and early 1900's. Full utilization was not practical from the economic standpoint and forest management had not been fully developed under sustained-yield methods on State lands. Generally, these lands have restocked and now support large volumes of second-growth timber. The mixture of the remaining old-growth with prime second-growth makes for an integrated forest capable of providing all of the values from timber growth, water yield, forage, recreation and wildlife. Currently, forest management of all timber stands and cut-overs is approaching intensive levels. Cut-overs and burns are restocked immediately. Fire proofing is a major program. Water production and conservation, as well as erosion control, are high priority projects which are integrated with forage production, recreation and wildlife habitat management.

Local Government Lands. County or municipally owned lands are located throughout the Puget Sound Study Area. Generally, these lands occur as small, scattered tracts, most of which are located in the Principal Forest Zone. Total area is about 575,000 acres, of which 485,000 acres is classified as forest land. The available sawtimber volume is about 5% of the total for the Puget Sound Area.

The largest land holding by local government is the City of Seattle Watershed of about 73,000 acres, located almost entirely in the Cedar River Basin. These lands extend into the Upper Forest Zone. Management objectives call for sustained-yield timber production, but with emphasis on water yield. Operations are conducted in a manner that will maintain or improve water yields. All land management and administration is supervised by a forestry staff in the City Water Department.

Other municipally owned land in the Puget Sound Area occur in small tracts. The total acreage and sawtimber volume has no significant effect on total resource production at this time. Generally, these lands do not receive intensive forest or water management.

Nearly all county owned land is managed by the State Department of Natural Resources under trust agreements. As a result, these lands are managed for sustained-yield production under the previously discussed State programs.

Private Lands. Based on broad classification, private lands comprise the bulk of the acreage in the Puget Sound Area. Approximately 4,147,000 acres, or 49% of the total acreage are privately owned. This group also holds the largest amount of commercial forest land, approximately 2,883,000 acres being so classified. This land contains some 34% of the Area's total sawtimber. Further breakdown of the forest land holdings indicate:

Large ownerships (Mostly corporate)	1,233,100 acres
Medium ownerships (in excess of 300 acres)	33,870 acres
Urban, suburban & Misc. private	1,616,140 acres

The urban, suburban and miscellaneous private holdings are all in the Woodland-Woodlot Zone, since this ownership pattern is the basis for the classification. Medium ownerships, those of 300 acres or more, are nearly all located in the lower part of the Principal Forest Zone. Large ownership holdings are also nearly all Principal Forest, with the exception of small blocks extending into the Upper Forest Zone.

As might be expected, management goals and objectives vary widely within the private sector. Timber production in the small ownership class is low because the lands generally serve other purposes. Tracts involving suburban residences, summer homes, open spaces within developed areas, etc., remain in timber primarily for aesthetic purposes and may therefore be considered as "reserved" in nature. Other areas, particularly farm woodlands, provide small amounts of sawtimber annually, however, these lands are generally not attractive for sawtimber production because of the long-term investment involved. Even so, these lands are potentially highly productive. Various government assistance programs

and private consulting forestry firms provide assistance to the landowner desirous of managing his stands. Generally, such lands are managed for the production of short-term, specialty items, such as Christmas trees, hardwood for furniture stock, and similar products.

Medium sized ownerships are also not receiving a fair share of timber and water management skills. These lands are generally located in upland areas or in other locations not particularly suited for agriculture or other special uses. Again, size is the major limiting factor in sawtimber production, as the tracts are generally not large enough to provide a significant annual harvest on a sustained-yield program. Collectively, they are capable of supporting milling operations and are used for that purpose in some instances. A few medium owners employ staff foresters to manage their holdings. Generally, management measures provide for fire control, reforestation, road access and various timber culture practices.

The large ownership class is an entirely different matter. These lands are primarily held by corporations operating integrated manufacturing plants which produce pulp, paper, plywood, lumber and a variety of other products. This group holds the largest block of highly productive timberland in the Puget Sound Area.

Within the large ownership class are four owners worthy of special mention. This group holds approximately 940,000 acres, all of it under varying degrees of forest management. Some of the land is under intensive management of the highest order. Each has research departments that have developed new and improved methods for increasing wood production. Each provides some additional multiple service to the public. Since wood production is the major goal, each maintains programs in protection, reforestation and timber culture as a standard practice. At the same time, good engineering and logging practices help in the prevention of soil erosion and in water production.

Also in the large owner class are several other holdings that could be classed as land and timber operations. These owners control about 200,000 acres, most of which was heavily cut-over prior to the turn of the century. Timber production per acre is somewhat lower on these lands due to early-day abuses, however, the change from vast cut-overs to producing forest land has been dramatic. This is due principally to the application of good management practices during recent years. These owners are actively enlarging their holdings through current land acquisition programs.

Education and Research

Education. Training in forestry and other related subjects is provided by many colleges, universities and other institutions throughout the Nation. Training specifically applicable to the conditions prevailing in the Puget Sound Area is offered by both Washington State University and the University of Washington, as well as several other West Coast Universities. Degrees are offered in the broad fields of forest management and forest engineering as well as in a variety of specialized subjects. As an example of the latter, the University of Washington offers the following general and specific training in water resource management.

Course work related to water as a resource is taught in Economics, Geography, Fisheries, Civil Engineering and Forestry. In addition, related subjects providing a wide variety of scientific background for understanding the hydrologic cycle and related phenomena are offered in Atmospheric Science, Biology, Botany, Forestry, and Geology. Because of the diverse interests of water resource specialists, this array of course work has a wide spectrum of subject matter content. Course work in water resources can be divided into: (1) applied water resource management, (2) social-economic aspects of water, and (3) basic science of hydrology.

Applied water resource management includes courses taught in the Civil Engineering, Fisheries and Forestry Schools. These include courses in sanitary engineering, hydraulics, applied hydrology, water management and fish resources, and water quality management.

Social-economic courses include natural resource utilization (Economics) and conservation of natural resources (Geography), which describe the physical water resource. Courses taught in the law department deal with water policy and legal aspects of the water rights and resource management.

Basic science courses include climatology, soils (as taught in Forestry), fluid mechanics, botany, biology, and geology.

Research. Research in the field of forestry and related subjects, is carried out by the educational institutions, most public land management agencies and by many private concerns, including industry and consulting firms. While modern forest management is considered "intensive" in many cases, it is so only in

PHOTO 3-6. Measuring the Snowpack under Forest cover. (U.S.F.S. photo).

relation to man's present ability in the field. Present management methods usually depend upon the manipulation of natural factors to achieve the desired results. Other techniques, such as the development of hybrid timber species, fertilization or irrigation to improve growth rates are now little more than experimental. There is a considerable potential for increasing timber yields that will be realized only through intensive research.

Similarly, there is considerable potential for improving the yield of other forest products or services, particularly in the field of water supply, quality improvement and timing of runoff. The major research potential in water resources for the Puget Sound Area is centered at the University of Washington. The colleges of Engineering, Forestry and Fisheries, and the Departments of Atmospheric Sciences, Geography, Economics, and Botany all have active research programs in various water problem areas. The State of Washington Water Research Center is operated jointly by the University of Washington and Washington State University. Faculty members from both institutions serve on the research committee and the Center supports research on both campuses. Such research is normally carried on as part of graduate student training programs through grants to faculty.

Research topics involve all aspects of water from law and social-economic problems to water quality, pollution control and plant-soil inter-relationships. Water conservation and management of land for water purposes also receive research attention.

The Forest Service, Pacific Northwest Forest and Range Experiment Station conducts research programs in forest silviculture, water yield, erosion prevention and watershed stability that is applicable to the Area. The Station maintains an inventory of all forest lands both public and private, along with reports in the field of forest economics. A silvicultural and animal problem laboratory is maintained at Olympia, Washington.

Forest Resources

Timber. The Puget Sound Area encompasses 8,435,000 acres or 53% of the land area of Western Washington (USFS-1965). A smaller proportion of Western Washington's commercial forest land is located in the Area-46% or 5,025,000 acres (Table 3-1). The Area's commercial forest land supports a sawtimber inventory of 101.7 billion board feet (inter-

TABLE 3-1. Land area of the Puget Sound Area by sector, county, and forest-land class, 1968–(In thousand acres)

County & sector	Total land area[1]	Total forest land	Forest land: Commercial	Forest land: Unproductive	Forest land: Productive reserved
NORTH					
Island	134	90	85	0	5
San Juan	112	77	69	0	8
Skagit	1,118	864	700	103	61
Whatcom	1,352	960	602	243	115
TOTAL	2,716	1,991	1,456	346	189
CENTRAL					
King	1,357	967	839	111	17
Kitsap	253	210	210	0	0
Lewis	141	127	125	2	0
Pierce	1,032	809	628	77	104
Snohomish	1,339	1,051	833	147	71
TOTAL	4,122	3,164	2,635	337	192
WEST					
Clallam	378	325	163	69	93
Jefferson	482	370	225	81	64
Mason[2]	473	401	347	33	21
Thurston	264	178	178	0	0
TOTAL	1,597	1,274	913	183	178
All sectors	8,435	6,429	5,004	866	559

[1]Based on data presented by the Land Usage and Development Committee, Puget Sound and Adjcent Waters Task Force, June 28, 1966.

[2]Includes small area in Grays Harbor County.

national ¼inch Rule). This is 4% of the Nation total and 35% of the Western Washington total (Table 3-5).

For descriptive purposes, the Area is broken into three sectors; the north, central and west.

The north sector includes primarily four counties—Island, San Juan, Skagit and Whatcom. The commercial forest area of this sector is 1,456,000 acres, or 29% of the Area's commercial forest land (Table 3-2), 89% of the sector total lies within Skagit and Whatcom Counties. Island and San Juan Counties contain less than 3% of the Area's commercial forest land. With increasing recreation pressures, it is likely that these lands will be even less significant to the Area's forest-based economy.

The central sector is composed primarily of Snohomish, King, Kitsap, and Pierce Counties, and includes that portion of Lewis County that lies within the study area. This sector contains the most commercial forest land—2,635,000 acres, or 52% of the Area's total (Table 3-2)—87% of this total is contained within three counties—Snohomish, King, and Pierce. These same three counties are experiencing the greatest population growth in the Area, with consequent increasing pressure for land use other than timber production.

The west sector is composed of portions of Thurston, Clallam, Jefferson, Mason, and Grays Harbor Counties that lie within the study area. This sector contains the smallest amount of commercial forest land—913,000 acres of 18% of the Area total (Table 3-2). The northeast portion of this sector differs from the remainder of the Puget Sound Area in having a much lower rainfall. This results in marked changes in forest character, species composition and, as a result, land use. Relatively dry, flat areas adjacent to Puget Sound are extensively used for Christmas tree culture. Further inland in the Shelton area, the land supports a highly productive timber stand, particularly within the Shelton Sustained Yield Unit. The steeper areas fronting the Olympic National Park are more varied with high potential for recreation use. Much of this sector is managed for the development of recreation rather than timber production.

TABLE 3-2. Area of commercial forest land in the Puget Sound Area by sector, county, and ownership class, 1968—(In thousand acres)

County and sector	Total	Ownership Class National forest	Ownership Class Other public	Private
NORTH				
Island	85	0	2	83
San Juan	69	0	0	69
Skagit	700	198	151	351
Whatcom	602	213	141	248
TOTAL	1,456	411	294	751
CENTRAL				
King	839	216	129	494
Kitsap	210	0	21	189
Lewis	125	38	13	74
Pierce	628	116	83	429
Snohomish	833	297	144	392
TOTAL	2,635	667	390	1,578
WEST				
Clallam	163	63	45	55
Jefferson	225	70	18	137
Mason[1]	347	82	59	206
Thurston	178	1	33	144
TOTAL	913	216	155	542
All sectors	5,004	1,294	839	2,871

[1] Includes small area in Grays Harbor County.

Of the total commercial forest land in the Area, approximately 55% or 2,730,000 acres, is in sawtimber stands. Poletimber stands occupy the second largest area—1,578,000 acres, or 31%. Seedling and sapling stands occupy 626,000 acres, or 13%. About 1% of the commercial forest land is non-stocked (Table 3-3). Douglas-fir accounts for the largest share of sawtimber volume with 33% of the total. Western hemlock ranks second with 31%. True firs account for 25%, other softwoods 6% and hardwood species 5% (Table 3-7). Hardwood species include red alder, big leaf maple, black cottonwood and madrona; with red alder accounting for over 60% of the hardwood volume.

TABLE 3-3. Area of commercial forest in the Puget Sound Area by sector, county and stand-size class, 1968—(In thousand acres)

County & sector	Total	Stand-size class: Saw-timber	Pole-timber	Saplings & seed-lings	Non-stocked
NORTH					
Island	85	44	36	5	0
San Juan	69	33	28	8	0
Skagit	700	410	188	91	11
Whatcom	602	376	160	51	15
TOTAL	1,456	863	412	155	26
CENTRAL					
King	839	515	236	79	9
Kitsap	210	104	83	22	1
Lewis	125	93	5	27	0
Pierce	628	324	204	89	11
Snohomish	833	490	254	77	12
TOTAL	2,635	1,526	782	294	33
WEST					
Clallam	163	67	82	13	1
Jefferson	225	149	63	13	0
Mason[1]	347	104	125	111	7
Thurston	178	21	114	40	3
TOTAL	913	341	384	177	11
All Sectors	5,004	2,730	1,578	626	70

[1]Includes small area in Grays Harbor County.

The species composition and distribution of stand-size classes varies considerably between the three sectors of the Area. This variance reflects differences in site, past cutting practices, and management objectives.

The north sector is 59% stocked in sawtimber stands, 28% in poletimber, with the remainder mostly in seedlings and saplings. Sawtimber volume is 29.6 billion board feet (International ¼ inch Rule). The true firs are the dominant species accounting for 38% of the total. Hardwood volume amounts to some 1.5 billion board feet.

The central sector has a similar stand-size class distribution as a result of similar histories. Sawtimber volume here is 57.5 billion board feet, with Douglas-fir and western hemlock being the dominant species. This sector has the largest hardwood inventory in the Area, containing some 2.6 billion board feet.

The west sector has a completely different stand-size class distribution due to an earlier logging history, poorer sites, little reforestation and the holding of commercial forest land for other than timber production. Most of the commercial area is in the poletimber size class (42%), followed by sawtimber (37%) and seedlings and saplings (19%). Sawtimber volume amounts to 13.8 billion board feet, with Douglas-fir being the dominant species. Hardwood volume is 591 million board feet.

Relation of Other Forest Uses—Several previous references have noted that modern forest management provides a variety of goods and services. It is not the intent of this appendix to discuss the water relationships of each of these, for they are covered in more detail elsewhere in the report. It is important, however, to realize that each single use is not a separable element. Water production, itself a major forest land use, is governed by the composite effect of all other uses, as well as by natural factors in any given watershed. It is extremely difficult to determine the total effect of any one use when other uses are also present. This point should be borne in mind.

As water production is influenced by other forest uses, so do these uses influence one another. As an example, timber production, an element in multiple-use management, is influenced by and may be restricted by recreation use. The opposite of this statement may also be true. Such restrictions are recognized in the preparation of this appendix to the degree that they are now known.

Water Production, Regulation, and Erosion Control. Water is an important product of forest lands. In the Puget Sound Area, over 80 percent of the available surface water flows from forested watersheds. The quantity and quality of these waters is, therefore, influenced to a large extent by the hydrologic condition of the source watersheds. Problems involving water quantity or quality are often the result of conditions prevailing in the source area.

TABLE 3-4. Puget Sound Area—Area of forest land, in acres, by ownership and type.

Cover Type or Land Class	Available: National Forest	Available: Other Federal[1]	Available: State & County	Available: Municipal	Available: Indian	Available: Private	Available: Total Available	Unavailable[2]	Total Available & Unavailable
Douglas-fir, seedlings and saplings	29,960	9,050	50,750	2,990	1,340	227,290	321,380	28,950	350,330
Douglas-fir, poletimber	65,630	24,180	117,660	29,750	5,140	587,610	829,970	19,660	849,630
Douglas-fir, small young growth sawtimber	137,620	11,120	69,940	17,800	2,910	432,700	672,090	42,960	715,050
Douglas-fir, old growth and large young growth sawtimber	185,270	25,050	27,540	8,740	360	160,110	407,070	122,710	529,780
True fir-mountain hemlock, seedlings and saplings	7,660	210	7,890	1,510	---	22,970	40,240	7,490	47,730
True fir-mountain hemlock, poletimber	17,630	2,330	1,760	---	---	5,330	27,050	9,860	36,910
True fir-mountain hemlock, small sawtimber	71,380	5,620	4,000	---	---	13,620	94,620	59,190	153,810
True fir-mountain hemlock, large sawtimber	261,950	23,180	12,050	38,250	---	54,100	389,530	134,600	524,130
Western hemlock, seedlings and saplings	22,080	2,180	29,260	9,100	---	121,110	183,730	5,940	189,670
Western hemlock, poletimber	14,170	480	39,110	5,040	---	95,450	154,250	5,550	159,800
Western hemlock, small sawtimber	48,690	1,520	17,390	2,410	70	89,340	159,420	20,380	179,800
Western hemlock, large sawtimber	322,500	8,030	46,150	3,050	10	161,980	541,720	74,000	615,720
Western redcedar, seedlings and saplings	1,240	---	20	---	---	590	1,850	---	1,850
Western redcedar, poletimber	1,410	---	130	---	310	20,820	22,670	80	22,750
Western redcedar, small sawtimber	7,390	410	1,870	20	130	19,290	29,110	1,440	30,550
Western redcedar, large sawtimber	38,920	2,720	2,760	1,520	10	17,140	63,070	5,300	68,370
Lodgepole pine, seedlings and saplings	310	---	2,670	---	60	5,250	8,290	630	8,920
Lodgepole pine, poletimber	3,540	1,650	390	---	20	2,680	8,280	540	8,820
Lodgepole pine, small sawtimber	650	230	---	---	10	---	890	70	960
Sitka-Englemann spruce, poletimber	---	---	---	---	20	740	760	---	760
Sitka-Englemann spruce, small sawtimber	4,120	1,950	---	---	---	1,680	7,750	640	8,390
Sitka-Englemann spruce, large sawtimber	1,960	1,180	---	---	---	260	3,400	2,500	5,900
Western white pine, seedlings and saplings	---	---	---	---	---	300	300	---	300
Western white pine, poletimber	970	1,250	100	---	---	180	2,500	410	2,910
Western white pine, small sawtimber	1,080	---	---	---	30	---	1,110	---	1,110
Western white pine, large sawtimber	580	---	---	---	---	510	1,090	---	1,090
White Fir, poletimber	80	---	---	---	---	2,170	2,250	360	2,610
White fir, small sawtimber	1,340	10	---	---	---	2,770	4,120	170	4,290
White fir, large sawtimber	670	10	---	---	---	2,810	3,490	860	4,350
Ponderosa pine, seedlings and saplings	---	---	270	---	---	---	270	---	270
Subtotal, softwoods	1,248,800	122,360	431,710	120,180	10,420	2,048,800	3,982,270	544,290	4,526,560
Hardwoods, seedlings and saplings	3,470	210	6,340	540	720	59,100	70,380	350	70,730
Hardwoods, poletimber	13,430	2,740	66,280	11,190	7,370	429,070	530,080	2,910	532,990
Hardwoods, small sawtimber	11,160	2,220	31,120	2,390	5,980	289,640	342,510	5,360	347,870
Hardwoods, large sawtimber	330	---	190	---	280	8,090	8,890	390	9,280
Subtotal, hardwoods	28,390	5,170	103,930	14,120	14,350	785,900	951,860	9,010	960,870
Nonstocked, cutover	13,120	420	11,780	3,250	30	32,350	60,950	150	61,100
Nonstocked, deforested by fire	4,220	10	1,280	---	---	3,720	9,230	4,880	14,110
Subtotal, nonstocked	17,340	430	13,060	3,250	30	36,070	70,180	5,030	75,210
Total, productive land	1,294,530	127,960	548,700	137,550	24,800	2,870,770	5,004,310	558,330	5,562,640
Subalpine	122,230	6,910	6,950	---	---	2,130	138,220	288,350	426,570
Noncommercial, rocky	204,290	20,840	9,840	4,320	10	10,220	249,520	190,220	439,740
Total, unproductive land	326,520	27,750	16,790	4,320	10	12,350	387,740	478,570	866,310
Total, all forested land	1,621,050	155,710	565,490	141,870	24,810	2,883,120	5,392,050	1,036,900	6,428,950

[1] Includes all Federal forest land except the National Forests.

[2] "Unavailable" refers to area held in reserved status such as in National Parks, State Parks, Wilderness Areas, Military Reservations, etc.

TABLE 3-5. Puget Sound Area—Volume of sawtimber and growing stock, by ownership, on productive forest land

Species or Group	Available								Available & Unavailable
	National Forest	Other Federal[1]	State & County	Municipal	Indian	Private	Total Available	Unavailable[2]	
Sawtimber—Thousand board feet, International ¼-inch rule									
Douglas-fir, small sawtimber	2,120,860	202,780	1,221,270	317,960	42,120	6,946,560	10,851,550	594,860	11,446,410
Douglas-fir, large sawtimber	10,227,700	1,259,560	1,631,890	513,470	22,620	9,091,870	22,747,110	6,124,960	28,872,070
True fir-mountain hemlock, small sawtimber	1,263,770	99,450	65,630	710	---	242,280	1,671,840	931,500	2,603,340
True fir-mountain hemlock, large sawtimber	16,136,590	1,428,040	765,290	2,072,690	---	3,229,400	23,632,010	7,762,210	31,394,220
Western hemlock, small sawtimber	753,600	23,570	283,670	52,140	660	1,477,990	2,591,630	410,040	3,001,670
Western hemlock, large sawtimber	16,929,830	420,070	2,474,050	177,200	410	8,385,470	28,387,030	3,979,440	32,366,470
Western redcedar, small sawtimber	153,860	8,530	29,980	330	3,500	331,550	527,750	25,550	553,300
Western redcedar, large sawtimber	3,484,900	243,690	197,100	82,340	1,230	1,076,100	5,085,360	428,930	5,514,290
Other softwood species, small sawtimber	125,120	38,030	1,860	---	160	67,880	233,050	15,090	248,140
Other softwood species, large sawtimber	215,020	79,550	1,870	---	600	145,010	442,050	190,820	632,870
Subtotal, softwoods	51,411,250	3,803,270	6,672,610	3,216,840	71,300	30,994,110	96,169,380	20,463,400	116,632,780
Hardwoods, small sawtimber	128,080	19,970	385,510	31,740	68,740	3,244,760	3,878,800	60,030	3,938,830
Hardwoods, large sawtimber	22,630	2,140	76,690	8,890	20,420	671,770	802,540	17,490	820,030
Subtotal, hardwoods	150,710	22,110	462,200	40,630	89,160	3,916,530	4,681,340	77,520	4,758,860
Total sawtimber, all species	51,561,960	3,825,380	7,134,810	3,257,470	160,460	34,910,640	100,850,720	20,540,920	121,391,640
Growing Stock—Million cubic feet									
Douglas-fir	2,257.5	260.3	519.7	151.5	11.8	2,921.6	6,122.4	1,222.0	7,344.4
True fir-mountain hemlock	3,144.1	279.1	150.3	375.0	---	628.0	4,576.5	1,573.0	6,149.5
Western hemlock	3,443.3	88.2	537.3	44.7	0.2	1,921.9	6,035.6	855.8	6,891.4
Other softwood species	1,475.8	221.2	91.4	32.7	2.2	641.6	2,464.9	286.3	2,751.2
Subtotal, softwoods	10,320.7	848.8	1,298.7	603.9	14.2	6,113.1	19,199.4	3,937.1	23,136.5
Hardwoods	59.6	8.7	182.7	16.1	35.2	1,548.0	1,850.3	30.6	1,880.9
Total growing stock, all species	10,380.3	857.5	1,481.4	620.0	49.4	7,661.1	21,049.7	3,967.7	25,017.4

[1]Includes all Federal forest land except the National Forests.

[2]"Unavailable" refers to area held in reserved status such as in National Parks, State Parks, Wilderness Areas, Military Reservations, etc.

TABLE 3-6. Volume of growing stock and sawtimber on commercial forest land in the Puget Sound Area by sector and owner group, 1968.

Sector and owner group	Growing stock	Sawtimber International ¼-inch rule
	Million cubic feet	Million board feet
NORTH		
National forest	2,868	13,525
Other public	1,417	6,359
Private	2,226	9,738
TOTAL	6,511	29,622
CENTRAL		
National forest	5,961	29,449
Other public	1,370	7,183
Private	4,293	20,845
TOTAL	11,624	57,477
WEST		
National forest	1,551	8,588
Other public	221	836
Private	1,142	4,328
TOTAL	2,914	13,752
ALL SECTORS		
National forest	10,380	51,562
Other public	3,008	14,378
Private	7,661	34,911
TOTAL	21,049	100,851

TABLE 3-7. Volume of growing stock and sawtimber on commercial forest land in the Puget Sound Area by species and sector, 1968

Species	Sector North	Central	West	Total
	Million cubic feet			
Douglas-fir	1,285	3,258	1,579	6,122
Western hemlock	1,694	3,664	678	6,036
True firs, mountain hemlock	2,206	2,241	130	4,577
Other softwoods	725	1,482	257	2,464
TOTAL	5,910	10,645	2,644	19,199
Red alder	425	727	210	1,362
Other hardwoods	176	252	60	488
TOTAL	601	979	270	1,850
ALL SPECIES	6,511	11,624	2,914	21,049
	Million board feet, International ¼-inch rule			
Douglas-fir	6,021	18,948	8,630	33,599
Western hemlock	9,028	18,609	3,342	30,979
True firs, mountain hemlock	11,138	13,320	846	25,304
Other softwoods	1,970	3,975	343	6,288
TOTAL	28,157	54,852	13,161	96,170
Red Alder	952	1,667	400	3,019
Other hardwoods	513	958	191	1,662
TOTAL	1,465	2,625	591	4,681
ALL SPECIES	29,622	57,477	13,752	100,851

The forested area of Puget Sound is geologically young and is typified by steep, rugged topography and fast flowing streams.

Precipitation is heavy, ranging from 25 to over 180 inches annually, with moderate to extremely heavy snowfall in the mountains. Forest soils are varied, but are generally coarse textured, ranging from deep and relatively stable in the lowland areas to thin and highly erosive in much of the higher elevations. In much of the area, soils are naturally unstable due to such factors as glaciation, extremely steep topography, heavy precipitation and to a warped or tilted character of the underlying bedrock. Even where apparent stability exists, the balance is often highly precarious. These conditions result in a heavy winter and spring runoff, accompanied by heavy sediment and debris loads due primarily to natural geologic processes.

Within this natural setting, the development and use of forest areas needs to be carefully controlled for the protection of watershed values. Whether or not other forest uses besides water production are compatible depends on three factors: (1) the demand or need for the use or resource in question, (2) the amount of change such use will impose on water values, and (3) the on-site and downstream requirements for water. Careful attention to watershed values in land use development can normally keep any changes within tolerable limits. Indeed, modern technology often enables man to

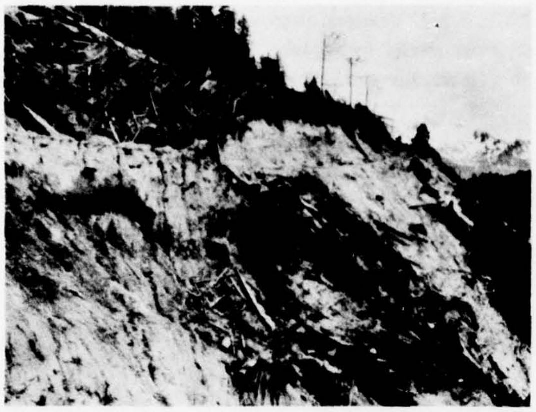


PHOTO 3-7. Erosion caused by road development in forest areas. (U.S.F.S. photo).

improve upon natural water yields in many instances, both in the timing of flows and in the quantity and quality of water produced.

Timber production is potentially one of the most disruptive uses of forest land, in that harvesting materially alters the vegetative cover and often causes extensive soil disturbance. The principal hazards involved are soil erosion, stream sedimentation, and the accumulation of debris in stream channels.

One of the principal sources of sedimentation arises from road construction. The precautionary measures required in the construction of roads vary with the relative stability of the landscape through which it passes. Generally, good road designs provide for; (1) recognition and avoidance, where possible, of unstable soils or slopes, (2) utilization of the most favorable terrain for road location, away from live streams wherever possible, (3) proper placement of soil materials either within the roadbed or as waste, (4) stabilization and revegetation of cut and fill slopes, (5) adequate drainage of surface waters, and (6) adequate live stream crossings which conform as nearly as possible to the original configuration of the streambed. Where roads are well designed and constructed, the level of erosion can be kept within acceptable limits.

The logging operation may also be a major source of sediment and debris. For optimum management of water resources, timber harvesting plans need to be tailored to fit the requirements of each area. Such plans should consider the following points; (1) Cutting unit layout–Unit boundaries should be placed in the most favorable locations respective to terrain. Yarding of logs in or through the streambeds should be avoided. Following logging, streams should be cleared of any unavoidable logging debris. Log landings should be located at points that will result in the least soil disturbance in the yarding process, (2) Method of logging–Tractor logging on flat ground or gentle slopes is normally suitable, however, cable systems are better adapted to logging slopes over 30%. Very steep topography and other critical soil areas may require the use of more sophisticated cable systems such as the "Wyssen", "Skagit", or the recently developed balloon system, which lifts the logs free of the ground during much of the yarding process, (3) Temporary roads, skid trails and fire breaks–These temporary facilities should be rehabilitated as soon as possible after logging by restoring the vegetative cover to reduce erosion. Useful treatment measures include planting, seeding, mulching, scarifying, and the installation of water bars, (4) Exposed soil areas resulting from logging or slash disposal operations–these areas may require stabilization to prevent undue soil loss and gullying. Treatment measures include planting, seeding, mulching, and contour furrowing.

Wild fires pose a serious threat to all forest resources, including timber and water. Fire consumes or kills most of the vegetation, burns away the duff and litter cover and thus exposes large areas of mineral soil. Management can do much toward the reduction of fire losses through planned fire prevention programs including the reduction of logging slash or other hazardous fuels, and extra precautionary measures such as closure of forest areas

PHOTO 3-8. Forest regeneration with minimum soil disturbance. (U.S.F.S. photo).

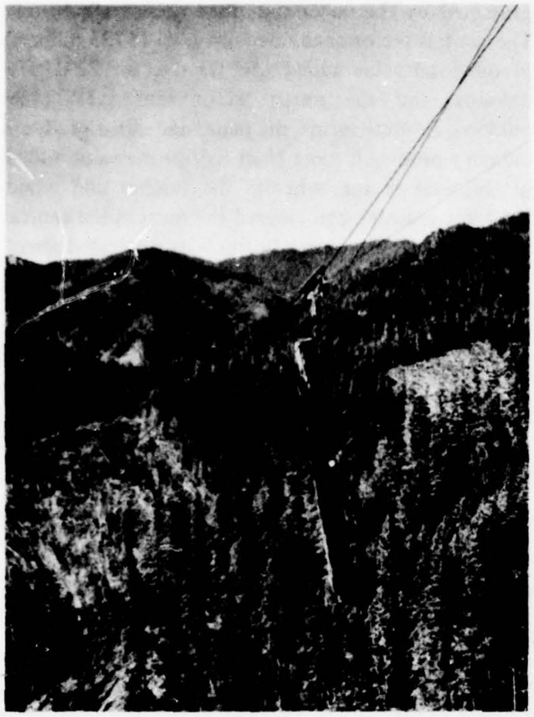


PHOTO 3-9. Skyline yarding in steep terrain. (State of Washington photo).

during periods of extreme fire danger. In addition, an adequate suppression organization is required to control and confine the size of fires to the lowest practicable limits. The treatment measures used in the rehabilitation of burns are the same as previously discussed under logging, however, more intensive treatment is usually required where the land is totally denuded.

Water yield improvement will not be discussed here as it is covered in other sections of the report, primarily in the Watershed Management and Water Quality and Quantity Appendices. It should be noted, however, that timber management practices can play a large part in any program for improvement of water yields. In snowpack management, for example, cutting practices at high elevation sites can be designed to increase snow accumulation. Reference should be made to those appendices specifically dealing with this subject.

FOREST PRODUCT INDUSTRIES

The forest product industries of the Puget Sound Area are an important element in the economy of the region, second only to aerospace in terms of total input. Originally, the forest product industries provided the major impetus to economic development in the Area and remained the leading industry for many years. Its relative position has declined somewhat in recent years, due to a gradual shift of the lumbering industry to areas of greater log supply and to expanded industrial development in other fields. Still, the industry supplies virtually all of the softwood product requirements of the Puget Sound Area and an important share of the national demand for these products as well. In 1963, it was estimated that 4% of the softwood lumber, 12% of the softwood playwood, and 5% of the wood pulp consumed in the Nation originated in the Puget Sound Area. Obviously, the greater amount of the Area's production is consumed by the national market.

Diversified development in the forest products industries has created a large demand for raw material supplies. In 1963, the roundwood[1] demand in the Area amounted to 2.9 billion board feet, a substantial portion of which was imported from adjacent hydrologic regions. Forest industry requirements for water are no less impressive, being estimated at 108,100 million gallons, or 331,750 acre feet annually.[2] This figure represents about 70% of the total industrial water use in the Puget Sound Area.

There are several means by which the economic benefit to a community from its manufacturing base may be determined. Employment is one such measure. In 1964, the forest products industries of the Area employed some 29,800 workers (Table 3-8). Industrial concerns, including logging contractors and the various manufacturing plants, are distributed throughout the populated portions of the study area. The central sector accounts for the greatest industrial development with some 555 concerns employing 20,100 workers. The west sector ranks second with 169 concerns employing 6,200 workers. The north sector contains 175 concerns employing some 3,500 workers.

[1] See Glossary for definition.

[2] Data supplied by the M&I Water Supply and Water Quality Control Committee, PS&AW.

Another method frequently used to reflect economic benefit is "value added by manufacturing". In general, this may be defined as the net increase in product value added by the manufacturing process. The following tabulation based on the 1963 Census of Manufacture (preliminary report), shows the estimated value added by manufacturing per employee for the two principal industrial categories:

Lumber and Wood Products (SIC 24)	$ 8,358
Paper and Allied Products (SIC 26)	$18,218

In 1963, the total value added by the manufacture of forest products was $350 million in the Puget Sound Area. Half of this value added was generated by the paper and allied products industry. The central sector accounted for 67% ($235 million) of the total value added; the west sector 22% ($76 million); and the north sector some 11% ($39 million). In these terms, the paper and allied products industry produced more than half of the value added in the west sector, whereas the lumber and wood products industry contributed the most in the central sector. The two industrial categories generated about the same amount of value added in the north sector.

For purposes of this report, the forest products industries are divided into five major categories; namely, logging, lumber, plywood and veneer, pulp and paper, and miscellaneous wood products.

TABLE 3-8. Number of forest industry establishments and average annual employment by industry groups, Sector and County in the Puget Sound Area, 1964[1]

Sector and county	Logging SIC 2411		Sawmills and Planing mills SIC 2421		Veneer and plywood plants SIC 2432		Miscellaneous lumber and wood products SIC 24 except 2411, 2421, 2432		Paper and allied products SIC 26	
	Reporting unit	No.of employees	Reporting unit	No.of employees	Reporting unit	No.of employees	Reporting unit	No.of employees	Reporting unit	No.of employees
North:										
Island	5	10	5	20	0	0	*2	0	0	0
San Juan	2	370	4	10	0	0	0	0	0	0
Skagit	56		7	170	1	*3	26[2*]	340	1	*3
Whatcom	41	300	7	220	2	*3	13	270	5	*3
Total	104	680	23	420	3	710	39	610	6	1,040
Central:										
King	68	610	31	1,690	7	1,280	63	1,180	27	1,070
Kitsap	23	40	14	230	0	0	3	70	0	0
Lewis	*4	180[5*]	0	0	0	0	0	0	0	0
Pierce	41	620	25	1,290	7	1,650	42	1,060	14	1,840
Snohomish	103	570	32	1,920	4	680	48	1,010	3	3,120
Total	235	2,020	102	5,130	18	3,610	156	3,320	44	6,030
West:										
Clallam	*4	90[5*]	11	230	1		12	240	3	*3
Jefferson	*4	60[5*]	9	40	2	850	4	50	1	*3
Mason	*4	260[5*]	14	430	1		4	20	2	*3
Thurston	*4	90[5*]	22	220	5	1,090	4	70	3	*3
Total	71[6*]	500	56	920	9	1,940	24	380	9	2,490
All sectors	410[6*]	3,200	181	6,470	30	6,260	219	4,310	59	9,560

*1 These fitures are based on Washington Employment Security Dept. data.
*2 Island County and Skagit County data are combined to avoid disclosure of individual mill data.
*3 Data combined in the sectors total to avoid disclosure of individual mill data.
*4 Data not available on partial county basis.
*5 Logging employment data allocated on the basis of estimated log production.
*6 Estimated number of units.

Source: Wall, Brian R., Prospective Timber Supplies and Forest Industrial Development in the Puget Sound Basin and Adjacent Waters. Administrative Report. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. September, 1966.

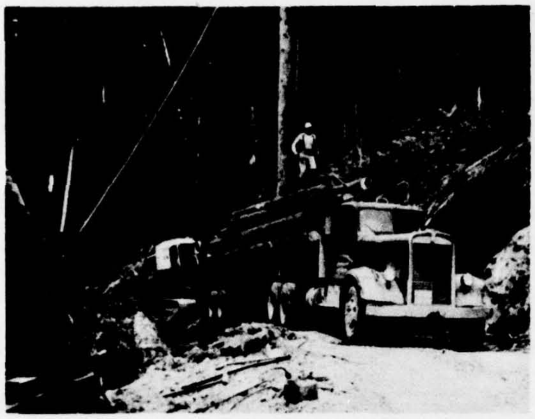


PHOTO 3-10. The logging industry—Loading logs in the woods. (U.S.F.S. photo).

Logging Industries.

The logging industry is concerned with the harvesting of timber products and the transportation of these to the mill or to other distribution points. The end product of the industry is roundwood, which in turn, provides the raw material for all other forest products industries. Of all forest products industries, logging has the closest relationship to the basic resource and is, therefore, more affected by changes in the availability of stumpage[1]. For similar reasons, it is the industry most affected by fluctuations in the timber products markets. As a result, the number of concerns engaged in logging, as well as the number of people employed, are subject to periodic fluctuations.

Logging is normally done by independent logging contractors or by timber concerns who engage in logging activities as a part of their integrated operations. Normally, the latter category is restricted to the large land holding concerns, who are better able to economically justify the large investment in logging equipment. In 1964, there were some 410 logging concerns active in the Puget Sound Area with an estimated employment of 3,200. Roundwood production for this same period was 1.8 billion board feet. Table 3-9 indicates past production for the period 1950-1963.

There is no significant consumptive water use involved in the logging industry, however, water is used to some extent for log transportation. The lower reaches of the main rivers and the salt waters of Puget Sound provides an economical means for the inter-basin transport of logs. The most significant effect on water resources caused by the logging industry involves the changes imposed on water quality and yields from the cut-over areas. These have been previously discussed in the section on forest land management.

Lumber Industries

The lumber industry has been the mainstay of the Area's forest products industries since their inception and still accounts for the major use of timber. In 1964, the lumber industry produced 1.3 billion board feet of lumber, a figure which represents 37% of the output of the State of Washington and 4% of the National output. The central sector led in production with 71% of the total, followed by the west sector with 21%. The north sector accounted for 8% of the total.

The Area's sawmills and planing mills offer a wide variety of lumber products ranging from rough, green stock through planed or surfaced stock of all sizes, long-dimension materials, and air or kiln-dried stock. Individual mill output varies widely, however, depending mainly upon plant size and capacity, permanence in relation to timber supplies, and plant specialties. Of the Area's 181 sawmills and planing mills, 102 are located in the central sector. These mills employ some 5,100 workers. The west sector supports 56 mills with an employment of 920. The north sector contains only 23 mills employing 420 workers (Table 3-8).

The lumber industry is not a heavy consumptive user of water; however, water is used almost universally for the storage, handling, washing, and debarking of logs prior to processing. Beyond the provision of adequate water supplies for this purpose, the major impact of the industry is again the effect on water quality for downstream use. Water held in log storage ponds generally suffers a loss of oxygen content and is commonly infused with objectionable odor and taste. Where return flows from such ponds pass directly into adjacent streams, the result is a deterioration in downstream water quality. Except for localized areas, this factor is not a major problem in the Puget Sound Area, not because such pollution does not exist, but because most plants are located near the mouths of the rivers, at points where no further use is made of the water prior to its entrance into Puget Sound.

[1] See glossary for definition.

TABLE 3-9. Annual log production in the Puget Sound Area, by owner class and county, 1950-63 (International ¼-inch rule) (In thousand board feet)

Owner class and county	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
All Counties														
Private	1,386,786	1,318,698	1,251,262	1,078,742	1,021,698	1,081,957	1,196,183	885,023	773,937	1,030,426	1,126,086	933,037	1,020,144	986,406
National Forest	283,599	317,553	308,114	361,760	329,417	327,080	372,739	407,209	445,794	587,120	493,568	445,770	566,320	594,578
Other public	69,902	58,788	100,576	633	3,889	180,053	230,378	121,727	44,080	113,468	89,627	84,618	115,340	245,486
Total	1,740,287	1,695,039	1,659,952	1,441,135	1,355,004	1,589,090	1,799,300	1,413,959	1,263,811	1,731,014	1,709,281	1,463,425	1,701,804	1,826,470
Clallam County [1]														
Private	1,306	1,190	1,323	1,012	1,144	1,271	1,461	1,478	1,123	1,752	1,952	1,737	1,290	1,743
National Forest	15,002	19,917	8,867	57,053	55,746	36,788	17,672	10,427	13,364	18,767	13,203	15,255	20,173	30,004
Other public	271	116	75	190	840	348	440	212	82	513	442	441	405	703
Total	16,579	21,223	10,265	58,255	57,730	38,407	19,573	12,117	14,569	21,032	15,597	17,433	21,868	32,450
Island County														
Private	19,578	24,058	27,423	24,344	20,435	27,291	16,030	25,602	18,416	22,084	23,512	20,784	15,132	19,743
National Forest	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Other public	...	529	2,141	...	...	...	250	...	...	...	2,628	34	...	502
Total	19,578	24,587	29,564	24,344	20,435	27,291	16,280	25,602	18,416	22,084	26,140	20,818	15,132	20,245
San Juan County														
Private	24,911	22,887	21,226	18,092	16,589	19,728	32,812	8,591	6,348	10,994	9,498	6,756	6,748	4,625
National Forest	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Other public	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	24,911	22,887	21,226	18,092	16,589	19,728	32,812	8,591	6,348	10,994	9,498	6,756	6,748	4,625
Jefferson County [1]														
Private	27,044	41,048	34,535	14,005	17,608	26,936	29,035	24,872	18,267	35,130	27,166	33,341	27,336	28,702
National Forest	9,250	13,396	26,473	25,643	25,515	29,980	26,600	35,506	34,953	43,540	39,096	31,134	45,290	52,627
Other public	145	26	212	...	...	2,068	1,411	1,123	961	962	1,541	1,874	2,263	2,760
Total	36,439	54,470	61,220	39,648	43,123	58,984	57,046	61,501	54,181	79,632	67,803	66,349	74,889	84,089
King County														
Private	201,012	224,505	252,159	206,677	233,947	276,641	298,112	238,102	246,563	201,323	330,483	223,746	253,206	190,264
National Forest	21,605	32,106	40,314	34,158	5,552	10,386	21,364	35,792	25,739	30,287	33,915	21,360	24,502	58,540
Other public	7,141	1,207	3,553	...	...	19,173	52,066	10,583	898	1,486	6,219	12,458	22,070	44,359
Total	229,758	257,818	296,026	240,835	239,499	306,200	371,542	284,477	273,200	233,096	370,617	257,564	299,778	293,163
Kitsap County														
Private	82,756	108,959	71,792	33,493	29,224	33,320	61,977	41,404	30,262	43,024	32,954	33,977	24,184	18,434
National Forest	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Other public	853	115	66	43	607	...	3,432	1,779	124	...	896	751	1,308	4,483
Total	83,609	109,074	71,858	33,536	29,831	33,320	65,409	43,183	30,386	43,024	33,850	34,728	25,492	22,917
Mason County [1]														
Private	96,395	72,802	39,858	55,614	62,236	67,100	58,462	56,100	38,088	52,428	53,494	57,522	50,556	44,097
National Forest	2,225	10,836	40,249	26,510	10,643	442	66,469	67,607	83,946	84,088	82,348	37,308	57,374	62,407
Other public	6,030	481	32	...	...	2,513	590	1,180	212	1,047	910	3,257	5,872	1,663
Total	104,650	84,119	80,139	82,124	72,879	70,055	125,521	124,887	122,246	137,563	136,752	98,087	113,802	108,167
Pierce County														
Private	227,952	190,238	243,620	174,824	172,781	215,837	231,982	199,160	177,026	321,993	280,935	270,721	315,748	298,550
National Forest	32,106	49,728	37,900	25,468	36,451	24,937	31,382	30,237	28,684	29,913	28,745	40,296	48,521	51,418
Other public	...	...	86	...	157	36,265	52,645	767	3,255	33,505	2,922	18,729	16,420	40,040
Total	260,058	239,966	281,606	200,292	209,389	277,039	316,009	230,164	208,965	385,411	312,602	329,746	380,689	390,008
Lewis County [1]														
Private	87,239	110,146	74,208	95,801	74,387	64,593	66,798	56,026	52,182	62,390	45,704	36,616	54,819	53,331
National Forest	13,067	13,900	8,989	11,999	11,081	15,904	12,149	6,880	18,031	33,506	29,658	26,664	30,448	32,159
Other public	7,141	357	10,485	...	122	14,820	19,439	11,121	18,413	4,056	10,419	8,167	7,915	9,220
Total	107,447	124,403	93,682	107,800	85,590	95,317	98,386	74,027	88,626	99,952	85,781	71,447	93,182	94,710
Skagit County														
Private	215,923	205,065	134,139	138,327	107,559	99,265	77,643	55,678	67,015	69,638	101,706	80,271	74,966	78,935
National Forest	28,968	25,588	24,502	43,935	21,243	62,689	44,297	54,883	69,395	119,579	97,072	65,342	75,558	65,178
Other public	18,937	19,160	31,389	...	844	50,011	30,708	37,927	4,658	14,657	16,557	14,492	23,891	21,958
Total	263,828	249,813	190,030	182,262	129,646	211,965	152,648	148,488	141,068	203,874	215,335	160,105	174,415	166,071
Snohomish County														
Private	147,909	137,552	139,535	140,173	101,542	97,753	128,157	82,182	46,496	97,215	130,024	95,428	126,217	151,167
National Forest	89,077	93,784	98,370	83,645	96,922	85,716	80,145	50,040	93,613	123,074	106,401	136,311	182,619	163,548
Other public	15,766	9,576	27,017	117	404	27,563	41,358	37,948	9,248	41,309	31,992	16,309	8,428	71,158
Total	252,752	240,912	264,922	223,935	198,868	211,032	249,660	170,170	149,357	261,598	268,417	248,048	317,264	385,873
Thurston County [1]														
Private	80,196	67,348	78,253	37,454	61,321	71,514	85,030	49,776	37,182	39,985	28,449	24,526	30,420	44,106
National Forest	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Other public	1,656	688	80	44	87	1,947	6,936	3,797	1,222	1,135	858	703	828	4,006
Total	81,852	68,036	78,333	37,498	61,408	73,461	91,966	53,573	38,404	41,120	29,307	25,229	31,248	48,112
Whatcom County														
Private	174,565	112,900	133,191	138,926	122,925	80,708	108,684	46,052	34,969	72,470	60,209	47,612	39,522	52,709
National Forest	72,299	58,298	22,450	53,349	66,264	60,238	72,661	115,837	78,069	104,366	63,130	72,100	81,835	78,697
Other public	11,962	26,533	25,440	239	828	25,345	21,103	15,290	5,007	14,798	14,243	7,403	25,940	44,634
Total	258,826	197,731	181,081	192,514	190,017	166,291	202,448	177,179	118,045	191,634	137,582	127,115	147,297	176,040

[1] Estimated volumes for the portion of the county in the Puget Sound Area

Source: Wall, Brian R., Prospective Timber Supplies and Forest Industrial Development in the Puget Sound Basin and Adjacent Waters. Administrative Report. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. 1966.

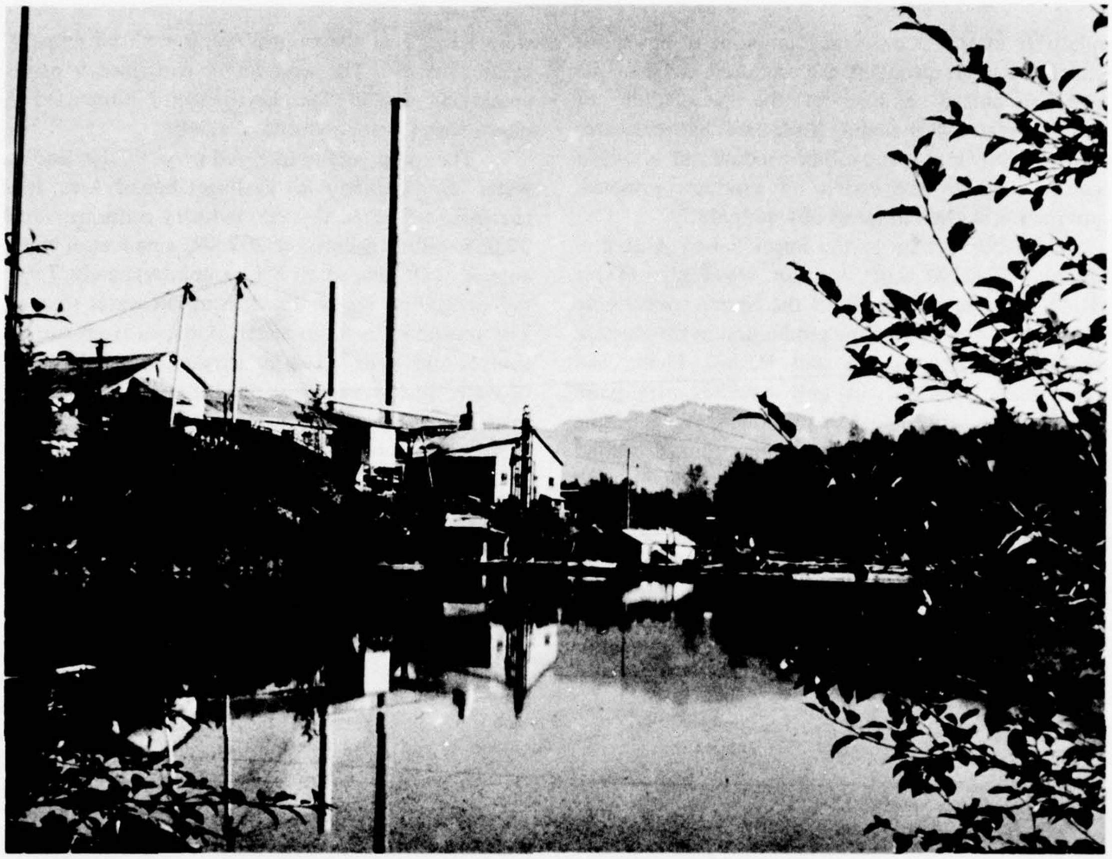


PHOTO 3-11. Timber processing plant at Darrington, Washington. (U.S.F.S. photo).

Plywood and Veneer Industries.

The plywood industry is one of the fastest growing of all forest products industries. Since its inception in the early 1900's, the demand for softwood plywood has developed at an ever-increasing rate. In 1963, Puget Sound Area mills produced 1,257 million square feet of softwood plywood (3/8 inch basis). This figure represents 67% of the State's total production and 12% of the National total. Again, the central sector accounted for the highest production with 61% of the total, followed by the west sector with 23% and the north sector with 16%.

Total employment for the industry was 6,260. Of the Area's 30 plywood and veneer plants, 18 are located in the central sector with an employment of 3,610. The west sector supports 9 plants employing 1,940 workers. The remaining 3 plants are located in the north sector where 710 are employed.

The plywood industry is a significant consumptive user of water. While no separate industry breakdown is available, the forest products industries, exclusive of pulp and paper, currently utilize some 11 billion gallons, or 33,890 acre feet of water annually.[1] The greater amount of this is used in the manufacture of plywood and veneer. The industry also utilizes water in the storage, handling, washing, and debarking of logs, the results of which have been previously described under the section on the lumber industry.

Pulp and Paper Industries.

The pulp and paper industry is also one of the fastest growing of the forest products industries in the Puget Sound Area. The production of paper is

[1] Data supplied by the M&I Water Supply and Water Quality Control Committee, PS&AW.

relatively minor, as only small amounts of newsprint and kraft paper products are produced. Most of the material pulped is used in the manufacture of building materials including hardboard, particleboard, composition board, and other products of a similar nature. Due to the variety of products involved, production is given in terms of woodpulp.

In 1963, mills in the Puget Sound Area produced 1,521,200 short tons of woodpulp. (Table 3-10). This represents 5% of the Nation's woodpulp production and 26% of the production in the Western States, including Alaska and Hawaii. Pierce and Snohomish Counties, the only counties with pulpmills in the central sector, produced 55% of the Area's production. The west sector ranked second with 33% of the total, followed by the north sector with 12%.

Employment in the pulp and paper industry totaled 9,560 in 1964. Of the Area's 59 plants, 44 were located in the central sector with an employment of 6,030. The west sector contained 9 plants employing 2,490. The north sector supported 6 plants with an employment of 1,040.

The pulp and paper industry is the leading water using industry in the Puget Sound Area. It is currently estimated that this industry consumes some 97,057 million gallons, or 297,860 acre feet of water annually. Of this total, 8% or approximately 7,966 million gallons are obtained from salt water sources. The remainder is fresh water, obtained from surface sources and wells.[1] The industry requires high levels of water quality, as well as quantity, in the processing operations. Depending upon the process used, the presence of pollutants in the water supply, both

[1] Data supplied by the M&I Water Supply and Water Quality Control Committee, PS&AW.

TABLE 3-10., Output of timber products in Puget Sound Area by sector and county, 1963

Sector and county	Lumber[1] Thousand bd. ft.	Plywood[2] Thousand sq. ft.	Miscellaneous Products[3] Thousand cu. ft.	Woodpulp[4] Tons
North:				
Island	9,600	0	200	0
San Juan	2,500	0	0	0
Skagit	67,300	150,000	5,900	31,000
Whatcom	31,800	60,000	5,800	155,200
Total	111,200	210,000	11,900	186,200
Central:				
King	328,500	174,000	5,300	0
Kitsap	76,000	0	1,300	0
Lewis	0	0	100	0
Pierce	150,500	360,500	20,100	310,500
Snohomish	384,400	228,200	18,000	527,800
Total	939,400	762,700	44,800	838,300
West:				
Clallam	65,900	87,000	10,800	341,500
Jefferson	6,600	0	100	124,200
Mason	154,400	18,000	2,600	31,000
Thurston	47,300	179,000	4,900	0
Total	274,200	284,000	18,400	496,700
All Sectors	1,324,800	1,256,700	75,100	1,521,200

[1] Western Wood Products Assoc. Statistical Yearbook. 1963.
[2] Forest Industries 33rd Annual Plywood Review. 1964.
[3] Based on unpublished file data of the Pacific Northwest Forest & Range Exp. Sta. (includes piling, poles, posts, fuelwood, ties, excelsior, shingles, log exports, etc.)
[4] Production based on data reported by the Northwest Pulp and Paper Assoc. and allocated on the basis of capacity listed in Lockwood's Directory.

biological and chemical, causes a significant reduction in the quality of woodpulp produced. The maintenance of adequate, suitable water supplies is, therefore, of considerable concern to the pulp and paper industry.

The effluents and residues from pulp mill operations also have a significant effect on downstream water quality. These will not be discussed in detail, as they are covered thoroughly in the Water Quality Control Appendix; however, it should be pointed out that these may have serious effects on downstream water uses. Nearly all of the Area's pulp mills are located on or adjacent to tidewater, with the result that most effluents are entered directly into salt water. Even so, recent studies have shown significant levels of pollution from this source in certain salt water areas.

PHOTO 3-12. Marketing of Christmas trees in the Shelton area. (U.S.F.S. photo).

Miscellaneous Wood Products Industries

Other than the major industries previously discussed, the Puget Sound Area also supports many smaller industries which produce a large variety of specialized wood products. A partial listing of these would include:

piling	excelsior	decking
posts	specialty veneers	fencing
Poles	laminates	furniture stock
fuelwood	moulding	treated products
ties	sash stock	chips
shingles	studs	hardwood specialties
shakes	boxes	Christmas trees

The log export field is also covered under this grouping of industries; however, production with reference to logs has been previously covered in the logging industry section.

Individual production figures are not available for this industrial grouping, as the units for measuring output vary widely, however, output in terms of cubic feet was estimated at 75.1 million cubic feet in 1963. The central sector accounted for 60% of this volume chiefly due to the export of timber, principally from the ports of Tacoma and Everett. The west sector had an output of 24%, whereas the north sector accounted for 16% of the total.

In 1964, there were some 219 manufacturing plants or other concerns within this industrial grouping in the Puget Sound Area. Total employment for the group was approximately 4,310. The central sector again led in industrial establishment with 156 concerns employing 3,320 workers. The north sector ranked second with 39 concerns employing 610 workers, followed by the west sector with 24 concerns and an employment of 380.

The consumptive water requirements of these industries vary considerably, but as a whole, the group is not a significant user of water. Again, water is used for log storage and handling as previously discussed in the lumber industry section.

PROBLEMS

The problems discussed in this section will be general in nature and are intended as a basis for the "future needs" section. It is not the purpose of this study to make a detailed analysis of the forest-based economy, but only to present those aspects of the economy which have a bearing on water resource analysis. As a result, this section will show only basic constraints, not a detailed analysis of each.

Management Intensity

With respect to timber yields, one of the most basic problems in the Puget Sound Area is the holding of productive forest land for purposes other than timber production. As for the land on which timber harvest is the primary goal, much is being managed far below the level required for the production of maximum yield. Certain withdrawals for purposes of recreation, watershed protection, or general aesthetic enjoyment are, of course, justified uses of forest land. These are discussed in the following paragraphs. What

is of concern here are those areas of forest land which are not designated for other uses, yet do not contribute materially to the timber supply.

To the individual small owner, management of his lands for timber production alone is a questionable practice in today's economy. One of the major constraints is the long-term investment required. Only the most productive lands that are well-managed can be expected to produce a satisfactory return on investments within the owner's lifetime. The majority of such owners do not have long-term management goals ccomparable to those of public or corporate owners, indeed, the ownership tenure itself is commonly short-term. The small size of the tracts generally prevent any effective integration with other enterprises such as manufacturing, but at the same time, presents serious problems in organization and administration for timber output— as, for example, the irregularity, small quantity and intermittant nature of the harvest. These factors, taken with the uncertainties that face the small-scale timber producer and the technical handicaps under which he operates, creates a strong financial disadvantage for the owner. The usual result is that the land is allowed to remain in "wildland" status or is kept in forest for the realization of other values. Where taxes or other fixed costs offset the values obtained the tendency is toward the eventual disposition of the land. Within the Puget Sound Area, there are some 1,616,140 acres of commercial forest land that are held by the small ownership class primarily in the woodland and woodlot zone.

The owners of medium-sized blocks of forest land have similar problems which differ from those of the small ownership category more in degree than in kind. Ownership, however, ranges from individually owned tracts, through company, small corporate and small public ownerships. As a result, much of the land is managed with respect to longer-term goals. Even so, a forest land owner wishing to emphasize timber production may have difficulty getting a rate of return on his investment that is equivalent to that obtainable through other investment opportunities. Current interest rates from other sources, which may range as high as 8-10%, can seldom be matched by timber yields alone, except on an "exploitative" basis. Exploitative in this instance, refers to an extensive form of management that strongly favors interim yields over those of the future, while keeping investments and costs at a low level. While this may be justified from the standpoint of short-term economics, it results in relatively little realization of the forest's productive potential. These factors, again combined with other technical handicaps, tend to place the owner at a financial disadvantage, thus encouraging the eventual disposition or other use of the land. There is an estimated 33,870 acres of commercial forest land in the Puget Sound Area that is held by this ownership class.

Large forest land owners, both public and private, present a different picture. These owners generally integrate timber production into long-term management plans for the development of all land and water resources. As a result, they are able to operate at a lower guiding rate of interest brought about through diversification, greater stability and smaller risk. True, such owners encounter many problems in the accomplishment of their goals, however, these generally do not affect the establishment of the goals themselves and as such, are not the subject at this point. Many of these problems are discussed elsewhere in this section.

To summarize, management intensity has an important bearing on obtaining high timber yields. Of the total commercial forest land in the Area, some 33%, or about 1,650,000 acres, is currently under low levels of management for timber production. Due to their location, these lands contain some of the most highly productive timberland in the Area. Where the lands are not held specifically for other forest uses, long-term timber yields could be increased greatly through more intensive management.

Land Use Development and Encroachment

This subject was touched upon briefly in the last section. It involves the conversion or reservation of forest lands for uses other than timber production. The past conversion of forest lands has largely taken place in the lowlands surrounding the metropolitan centers for such purposes as industrial and residential sites, road networks, farmlands, or like uses. With expanding populations and demands for space, much of this may be regarded as inevitable. Fortunately, most recent land conversion has taken place within the Woodland and Woodlot Zone and involves the "filling in" of lands within existing developed areas. As previously discusses, these lands do not add materially to the Area's timber yield at the present.

Land use conversion has also occurred in the Principal and Upper Forest Zones at numerous locations. This is chiefly due to the development of roads, reservoirs, and power transmission lines. There

PHOTO 3-13. Forest land encroachment from suburban development. (State of Washington photo).

is presently an estimated 190,000 acres in the Puget Sound Area that has been converted for these purposes.

Forest Land Reservations or Withdrawals

The reservation of forest lands for uses other than timber production is of considerable significance in the Puget Sound Area. There are 558,300 acres of productive forest land currently held in reserved status within the confines of National, State, or county parks; wilderness, wild or primitive areas; military reservations; and the like (Table 3-4) The primary purpose of these reservations is outdoor recreation, although small areas are held for other purposes. Most of this land is located at high elevations within the Upper and Subalpine Forest Zones, however, small areas of the Principal Forest are involved. While the land area involved is large, it consists primarily of timberland with low productive potential and is therefore of lesser significance in terms of timber yield.

The greatest impact from recreational demand may well occur within the multiple-use areas of public ownerships. The National Forests alone contain some 544,000 acres which contain high recreational values or are already subject to certain cutting restrictions due to the demands for recreation. Under the multiple-use concept, it is assumed that modifications in cutting practices, together with other technological developments, will permit the utilization of the timber resource without undue damage to recreational values. Whether or not this can be done in the face of increasing recreation pressure, remains to be seen.

Another category of land that may be considered "reserved" in nature involves the small private ownerships previously discussed under the section on management intensity. Much of this land is held for suburban residences, summer homes, organization camps, resorts, or other developments of a like nature. As a result, these forested tracts are held mainly for aesthetic or other personal values. Technically, the land is "available"; that is, through changes in ownership or management intent, it could be utilized for the production of timber. This is not considered likely in most cases.

It should not be inferred that the establishment of reserved areas is not in the public interest. Indeed, most of the reservations discussed in this section involve the protection of outstanding values and are valid and/or justified uses in the management of forest land. Even so, the inclusion of commercial forest land in such areas reduces the acreage available for the growing of timber products and consequently, reduces the potential yeild of such products.

PHOTO 3-14. Forest land of high recreation potential—San Juan Islands. (State of Washington photo).

Timber Production

Problems inherent in timber production, protection, and utilization, are many and complex, often requiring highly technical consideration. These occur throughout the full range of timber production activities, from reforestation through the final harvest cutting of the timber. Such problems are not unlike those occurring in any agricultural activity and as such, are normal business risks. Much time, effort, and the services of highly trained individuals have been devoted to the resolution of these problems. Much progress has been made, particularly with

reference to specific areas under present levels of management. Much more, however, can be accomplished.

Probably the most basic constraint concerns a general lack of knowledge. A forest is a crop, similar in many respects to others in the field of agriculture. Unlike the others, however, it requires a long span of years to mature. A wheat farmer has a vast store of knowledge upon which to draw knowledge obtained from the production of innumerable crops of wheat by his predecessors or from research. From it, he can determine over a short period of time, the strain of wheat best suited to his area and the treatment measures best suited to his production goals. Only limited knowledge is available to the grower of timber and the potentials for increasing timber yield are not yet fully understood. Certain horticultural practices, such as the development of hybrid species, improved seed sources, or the use of growth inducing techniques are largely experimental. Other practices, such as pruning or thinning, have been carried on for many years with a few species, but even here, the method to be used or the frequency and intensity of application are subjects of uncertainty. Most current information is based on short-term observations of response and upon reasonable assumptions of what the long-term response will be.

The above factors, when combined with the further uncertainties of market conditions at some future date, tend to discourage intensive cultural treatment of forest stands. The result is a rather conservative approach on the part of most forest land owners. Certainly, there is a large potential for increasing the yield of timber products which will be realized only through further research, experience, and economic incentive as well as through the application of known techniques.

The problem of protecting forest soils in relation to water production has been previously discussed. This is equally important for the production of timber. Obviously, if the soil is lost, so is the capacity of the land to produce timber. This factor is of particular importance in the Puget Sound Area. There are many thousand acres of commercial forest land, particularly in public ownership, that require special logging techniques and other precautionary measures to avoid undue damage to the soil resource. Except for the exclusion of highly questionable areas, these lands are included in the timber base used for the calculation of allowable harvest. The continuance of present cutting levels therefore depends, in part, on the eventual utilization of these lands for timber production.

Certain recent developments in logging methods have provided part of the answer. Applicable cable systems, such as the Wyssen, Skagit, or balloon method, are extending cutting operations to lands that would be excessively damaged if logged by older, conventional methods. Even so, many areas remain inoperable by present means. Unless improved methods for logging these areas can be developed, it appears probable that further reservations of forest land for soil and watershed protection will occur.

Forest Products Industries.

Problems related to the harvesting, processing, and marketing of forest products are also many and complex. As in any economic enterprise, the industry is dependent upon adequate raw material supplies, plant locations, manpower, and other processing supplies, transportation facilities, and markets in order to maintain a favorable economic position. Of course, each enterprise must be evaluated in terms of its own position relative to these basic needs. What may be a major problem to one may be of little concern to another. As a whole, the industry has been well able to cope with its collective problems as its present position in the economy will attest. There are, however, several which are of major concern at the present time. Most of these stem from a relative stability in product prices, increasing production costs and increasing competition for raw material supplies.

The stability in finished product prices stems from the industry's dependence on the National market. As previously discussed, the greater part of the Area's production is exported to other parts of the Nation, principally the eastern and central states. As a result, the Area's products are meeting increasingly stiff competition from other softwood products suppliers, chiefly the southern states and Canada, who are nearer the principal markets. In addition, Puget Sound products must compete with metals, plastics, glass, brick, and concrete. These other materials are alternatives for wood products in construction or other end uses and, in many cases, are competitive in price. The significance of this situation is that Puget Sound industries must sell a substantial part of their output in distant markets where it does not enjoy any competitive advantage. The demand for local products is quite elastic and any attempt to raise the selling price very much will cause its buyers

to shift their purchases to other wood products sources or to the other non-wood materials. The result is that the local industry is forced to stabilize their prices at levels comparable to those charged for competitive materials.

Low product prices reduce the ability of the local industry to absorb increased raw material or production costs, although it faces the same inflationary costs of labor, raw materials, and taxes that occur throughout the National economy. These costs are partially offset by comparative product price increases, locally and nationally, however, they appear to be rising at a greater rate in the Puget Sound Area than is the case Nationwide. In addition to the usual cost factors, the industry is now faced with the need of developing treatment measures for the reduction of air and water pollution resulting from its operations. The pulp and paper industry, particularly, is faced with this problem. Pollution abatement, however, desirable as it may be, represents an additional production cost which cannot be readily offset by increased product prices.

Another cost factor of concern is an increase in raw material costs brought about primarily by foreign competition in the log market. Log exports to foreign countries, principally Canada and Japan, have increased sharply in recent years. Exports from the Pacific Northwest to foreign markets rose from 340 million board feet in 1961, to over 1,190 million in 1966, a sizeable portion of which originated in the log supply area of the Puget Sound Mills. This figure (1.1 MMBF) represents about 10% of the raw wood material handled in the Pacific Northwest in 1966[1]. Japan is the greatest single log buyer, accounting for about 90% of the material exported. Production cost and marketing advantages enjoyed by the foreign concerns enable them to pay higher prices for logs than the local industry can afford. This competition

PHOTO 3-15. Export of logs from Olympia, Washington. (State of Washington photo)

has been a factor influencing the closure of several wood products plants in the Puget Sound Area due to their inability to obtain adequate raw material supplies.

Competition for raw material supplies from domestic sources outside the area is not a problem at the present time. It may become so in the future. The wood products industries of the Puget Sound Area are, themselves, importers of raw material. In 1963, the consumption of roundwood in the Area was 2.9 billion board feet, of which 1.1 billion (38%) was imported, mostly from elsewhere in the State, although a small amount came from Canada. As a result, the local industry depends heavily on the whole State's resources for its raw material supplies. This situation has been brought about by several factors, the most important being the advantages offered by the salt water port facilities in the Puget Sound Area. As long as the various factors favoring industrial development in the Puget Sound Area are not drastically changed, the local industry should continue to compete favorably for raw material supplies available elsewhere in the State.

[1] Data from "Forest Resources, Private Enterprise, and the Future" by Albert C. Worrell, Industrial Forestry Association, 1966.

PRESENT AND FUTURE NEEDS

A determination of the water-related future needs of the Forests Sector is difficult. Even by restricting this study to the direct water-related aspects of forests and the forest-based economy, there are three separate levels of needs that deserve consideration. These are: (1) an analysis of the regional and national demand for wood products; (2) a determination of the water requirements needed for the growing, harvesting and processing of these products; and (3) for a given level of development of

the industry, a determination of the measures needed to insure that water yields from forest lands will meet acceptable standards of quality and quantity.

SUPPLY AND DEMAND FOR WOOD PRODUCTS

An analysis of the demand for wood products has an important bearing on water resource development in the Puget Sound Area. As demand affects the forest-based economy, so does it affect population, employment, the development of support industries, and similar aspects of the Area's economy. These in turn, may be translated into needs for municipal and industrial water, recreation, or other water uses as discussed throughout the Puget Sound Basin Report. As is presently the case, the forest-based economy of the Puget Sound Area is expected to be strongly influenced by national demand in the future. In order to predict the expected level of development of the local industry, it is necessary to consider projected levels of supply and demand in the Nation.

National Demand for Wood Products

The national demand for lumber and wood products has been projected in the Forest Service report "Timber Trends in the United States" and in other specially prepared reports pertaining to the Pacific Northwest Region[1]. These reports utilize certain basic assumptions on which the national projections were based. Included are five major factors: population, household information, gross national product, disposable personal income, and construction activity.

By 1980, population of the United States is expected to rise to about 241 million persons and to 325 million by the year 2000. This projection approximates the median of a series of projections published by the U.S. Bureau of Census (1964) and is roughly 10% lower than that of the preceding series prepared in 1960 for the Senate Select Committee on Water Resources.

Households in the United States have been projected to increase from 54.7 million in 1962 to 101 million in 2000 (Table 3-11). The number of persons per household is expected to continue to decline, from 3.41 in 1962 to 3.22 in 2000.

[1] Specific reports include: "Prospective Economic Developments Based on the Timber Resources of the Pacific Northwest", Gedney, Newport and Hair, 1966; and "Prospective Timber Supplies and Forest Industrial Development in the Puget Sound Basin", Wall, 1966.

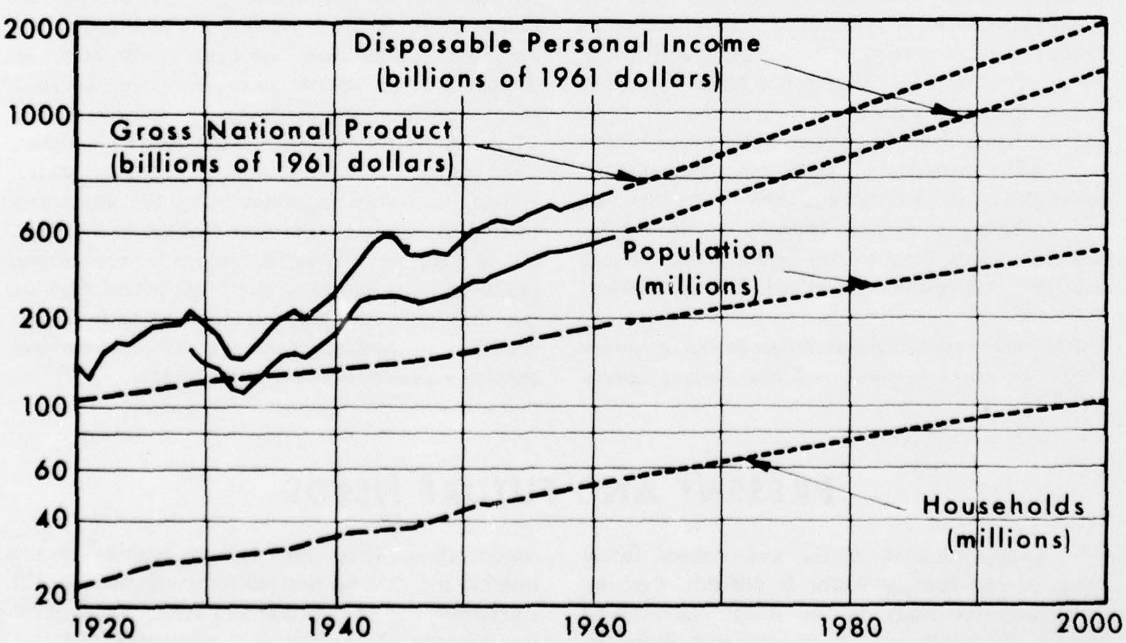


FIGURE 3-1. Population and economic growth in the United States, 1920-2000.
Source: "Timber Trends in the United States," p. 6.

TABLE 3-11. Population, households, gross national product and disposable personal income in the United States, 1920-2000*

Year	Population	Households	Persons per Household	Gross National Product (1961 dollars)	Disposable Personal Income (1961 dollars) Total	Per capita
	Million				Billion	
1920	106.5	24.4	4.36	154.0	--	--
1930	123.2	29.9	4.12	190.3	140.6	1,141
1940	132.1	34.9	3.79	268.8	170.2	1,288
1950	152.3	43.0	3.54	366.5	256.7	1,685
1960	180.7	53.0	3.41	511.1	355.7	1,968
1962	186.7	54.7	3.41	546.0	379.0	2,030
			Projections			
1970	208.0	62.5	3.33	710.0	500.0	2,400
1975	223.0	--	--	84.0	--	--
1980	241.0	73.5	3.28	990.0	690.0	2,860
1985	260.0	--	--	1,175.0	--	--
1990	280.0	86.2	3.25	1,380.0	960.0	3,430
2000	325.0	101.0	3.22	1,920.0	1,340.0	4,120

* Based on Tables 1 and 2, pp. 6 and 8, "Timber Trends in the United States."

Sources: POPULATION: 1920-49, U.S. Dep. Com., Bur. Census, **Historical Statistics of the United States**, 1960. 1950-62, "Estimates of the Population of the United States, January 1, 1950, to March 1, 1964."
Population Estimates, 1964 (Cur. Population Reps., Ser. P-25, No. 283). Projections are derived from estimates published by the U.S. Dep. *Com.*, Bur. Census in "Projections of the Population of the United States by Age and Sex: 1964 to 1985 with Extensions to 2010." **Population Estimates** July, 1964, (Cur. *Population Reps., Ser. P-25, No. 286).*
NUMBER OF HOUSEHOLDS: 1920-40, Bur. Census, **Census of Housing**, 1950, vol. I, Part 1, 1953 1950 and 1960, Bur, Census, "Components of Inventory Change." **United States Census of Housing**, 1960, vol. IV, part 1-A, 1962, and from unpublished data furnished by the Bur. Census. 1962, "Households and Families, by Type: 1962." **Population Characteristics**, 1962 (Cur. Population Reps., Ser. P-20, No. 119). Projections, 1970 and 1980, U.S. Dep. Agr., Forest Serv., derived from projections published by the U.S. Dep. Com., Bur. Census, "Interim Revised Projections of the Number of Households and Families: 1965 to 1980." **Population Characteristics**, 1963 (Cur. Population Reps., Ser. P-20, No. 123). 1990 and 2000, derived from population estimates and assumed trend in number of persons per household.
GROSS NATIONAL PRODUCT: 1920, derived from data published by the Joing Com. Econ. Rep., **Potential Economic Growth of the United States During the Next Decade**, 1954. 1930-62, Office of the President, **Economic Report of the President**, January 1962 and 1964.
DISPOSABLE PERSONAL INCOME: 1930-62, Office of the President, **Economic Report of the President**, January 1962 and 1964.
PROJECTIONS: U.S. Dep. Agr., Forest Serv., derived in part from data published by the Outdoor Recreation Resources Rev. Comm. Staff, Nat. Planning Ass., and U.S. Dep. Labor, Bur. Labor Statist., **Projections to the Years 1976 and 2000: Economic Growth, Population, Labor Force and Leisure, and Transportation**, 1962 (ORRRC Study Rep. No. 23).

Based on an increased population, recent trends in productivity and other factors, the gross national product is projected to increase 1.8 times, to $990 billion (1961 dollars) by 1980, and will continue to rise to $1,920 billion by the year 2000.

Disposable personal income in 1962 was $379 billion (1961 dollars). It is expected to rise to $690 billion in 1980, and to $1,340 billion in 2000. Disposable personal income per capita is expected to more than double between 1962 and 2000, rising from $2,030 to $4,120 (1961 dollars) (Table 3-11).

Past trends in use and statistical analysis of historical relationships indicate that the use of industrial raw materials will increase about 30 percent by 1980 and will nearly double by the year 2000. Four-fifths of the annual consumption of lumber and plywood, nearly all of the poles and piling, and substantial quantities of other industrial timber products are used for construction activity in the United States. Construction expenditures are expected to rise nearly 60% by 1980 and 160% by the year 2000. The consumption of construction materials is expected to nearly double during the same period. It was assumed that the relative price of timber products and

TABLE 3-12. Summary of total demand for major timber products in the United States, 1952-1985.

Product	Standard Unit of Measure	1952	1962	Projections 1970	1975	1980	1985
Lumber:							
Total	MM Bd. Ft.	41,460	37,300	39,700	41,600	43,400	45,500
Per capita	bd. ft.	263	200	191	187	180	175
Plywood & veneers:							
Softwoods	MM sq. ft. 3/8" basis	--	9,250	14,400	15,600	17,000	18,500
Hardwoods	MM sq. ft. 3/8" basis	--	2,770	3,500	4,200	5,000	5,700
Total		--	12,020	17,900	19,800	22,000	24,200
Per capita	Sq. ft.	--	64	86	89	91	93
Woodpulp:							
Total	MM Tons	--	29.5	38.2	44.8	52.4	60.5
Paper & board:							
Total	MM tons	--	42.4	52.7	60.2	69.3	79.2
Per capita	Pounds	--	454	507	540	575	609

Source: Wall, Brian R., Prospective Timber Supplies and Forest Industrial Development in the Puget Sound Basin and Adjacent Waters. Administrative Report. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. September 1966.

competing materials would remain stable, and therefore industrial timber products would maintain their relative position in the mix of industrial materials—about 22 percent.

From these basic assumptions, demands for timber products have been projected to 1985 for the United States (Table 3-12). The total demand for lumber is expected to rise from 37.3 billion board feet in 1962 to 45.5 billion board feet in 1985. While total demand is increasing, lumber demand per capita is expected to decline to 175 board feet. Plywood and veneer demand should double by 1985 to 24.2 billion square feet (3/8 inch basis). Unlike lumber, however, plywood demand per capita is increasing and is expected to reach 93 square feet by 1985. Currently, over 70% of the plywood and veneer is softwood, a share that is likely to be maintained during the next few decades. The demand for woodpulp should double, while that for paper and board should nearly double by 1985. Paper and board demand per capita should rise to 609 pounds during the same period.

If these trends continue, the projected demand for timber products in 1980, 2000, and 2020 is estimated in Table 3-13.

National Supply of Wood Products

National projections of future wood supply are currently being developed and are now available only in preliminary form.

TABLE 3-13. Projected consumption of Timber Products in the United States, 1980-2020. (Per capita consumption in cubic feet, total consumption in million cubic feet).

Product	Projection Period 1980*	2000*	2020**
Lumber			
Total	6,720	8,280	9,630
Per capita	27.9	25.5	22.4
Plywood & Veneer			
Total	1,840	2,650	3,870
Per capita	7.6	8.2	9.0
Woodpulp (including paper & board)			
Total	6,730	10,780	16,750
Per capita	27.9	33.2	39.0
Misc. Industrial Products			
Total	500	500	500
Per capita	2.1	1.5	1.2
Fuelwood			
Total	1,350	900	720
Per capita	5.6	2.8	1.7
All Wood Products			
TOTAL	17,140	23,110	31,470
PER CAPITA	71.1	71.2	73.2

* Data based on Table 43, USDA Forest Resource Report No. 17, "Timber Trends in the United States".

** Data developed by the Forests Work Group, PS&AW and based on the continuation of trends expressed in * above.

The report "Timber Trends in the United States" provides the basic source information. In 1962, total consumption of wood products in the

United States was 13,278 million cubic feet, of which 1,480 million cubic feet (11%) was imported material. Domestic production accounted for 89% or 11,798 million cubic feet. This domestic production figure was accomplished by the cutting of 10,320 million cubic feet of roundwood from the Nation's timberlands, the remainder being produced by re-use and manufacture of plant residues. This information, plus projections to the year 2020, are summarized in Table 3-14.

TABLE 3-14. Summary of consumption, net imports and domestic production of timber products in the United States 1962-2020 * (Million cubic feet)

	1962	Projections 1980	2000	2020
Consumption	13,278	17,140	23,110	31,470
Imports	1,480	1,990	2,640	4,210
Domestic production				
Roundwood	10,320	13,410	18,670	24,760
Residues	1,478	1,740	1,800	2,500

From Table 3-14, it can be seen that the percentage of wood material supplied by imports and the utilization of residues is expected to remain about the same in the future, although the amount of material increases substantially.

The requirements for domestic roundwood production is expected to rise 2.4 times–to 24,760 million cubic feet by 2020. This is the material the Nation's timberlands will be called upon to produce.

The Forest Service, in cooperation with the Water Resources Council, has developed preliminary projections of industrial wood requirements to the year 2020. These projections are made for each of the 16 major water resource regions of the United States, including the Columbia North Pacific Region of which the Puget Sound Area is a part. The projections closely approximate the total roundwood requirements discussed in the last paragraph and are summarized in Table 3-15.

This data is not directly comparable to the roundwood requirements shown in Table 3-14 for a variety of reasons; slightly different base assumptions and different areas of coverage, for example, but is considered adequate for long-range planning purposes.

Table 3-15 indicates that two of the Nation's water resource regions will provide the bulk of the roundwood requirements in the future. The South Atlantic Gulf and the Columbia-North Pacific Regions, together, currently supply 61% of the Nation's roundwood, and are expected to continue to supply over 50% of the total by the year 2020. This is logical since these two regions contain the most highly productive timberland in the Nation. The Columbia-North Pacific Region alone currently supplies 36% of the roundwood material used in the Nation and is expected to supply 24% of the total by 2020.

This information is of considerable significance in water resource planning for the Pacific Northwest. Land use planners concerned with relatively small areas often lack resource data beyond their area of immediate concern. It is sometimes assumed that the impacted land uses (as forest land use has historically been) can be adequately provided for in other less-developed areas of the Nation. Some of the fallacies in this approach can be determined from Table 3-15. The two major timber producing regions of the United States, the South Atlantic Gulf and the Columbia-North Pacific, cannot have their timber production base eroded significantly as the other regions do not have the productive capacity to pick up the slack. At least, not if the assumptions used in the development of the national projections are true and the goals for domestic roundwood production in the Nation are to be realized. This same analogy is equally true for smaller regions such as the Puget Sound Area.

TABLE 3-15. Industrial wood consumption in the United States, by Water Resource Region 1962-2020. (Million cubic feet)

Region	1962	Projections 1980	2000	2020
So. Atlantic Gulf	2,460	3,350	5,870	6,520
Columbia No. Pacific	3,480**	4,600	5,180	5,300
All other regions	3,790	6,200	8,640	9,860
TOTAL U.S.	9,730	14,150	19,690	21,680

* The footnotes applicable to Table 3-13 apply here as well.

** Data supplied by the Pacific Northwest Forest and Range Experiment Station USFS. These totals are slightly different from those used in the national projections.

Relationship of the Puget Sound Area

The Columbia-North Pacific Region is further divided into 12 water resource subregions, one of which covers the Puget Sound Area. Of the 12 subregions, five, which are located west of the

Cascade Mountains, contain the most productive forest land and the bulk of the sawtimber volume. Again, the Puget Sound Area is included. Thus in 1962, the Puget Sound Area, while containing only 8% of the Region's commercial forest land, held 13% of its sawtimber volume and provided 14% of the timber products produced in the Region.

The Forest Service has made preliminary projections of industrial wood consumption for each of the 12 subregions of the Columbia-North Pacific Region[1]. Projections relating to the Puget Sound Area are summarized in Table 3-16.

TABLE 3-16. Estimated industrial wood consumption, by source, in the Puget Sound Area—1965-2020 (million cubic feet)

Year	Total Consumption	Roundwood	Plant Residues
1965	647	517	130
1980	814	606	208
2000	956	655	301
2020	931	596	335

Table 3-16 indicates that a 50 percent increase in total industrial wood consumption is expected by the year 2000. The majority of the demand will be satisfied by roundwood production; however, the use of plant residues is expected to increase substantially in the future. Roundwood consumption is expected to increase 1.3 times to 655 million cubic feet by 2000 after which it will decline to 596 million cubic feet in 2020, primarily as a result of the increased use of residues.

The above estimates of roundwood consumption do not include non-industrial demand, such as fuelwood. These uses of wood are expected to be relatively minor in the Puget Sound Area, probably not exceeding 15 million cubic feet in 1980, or 12 million in later periods.[2] The total roundwood demand in the Area is therefore expected to be 621 million cubic feet by 1980, 667 million by 2000, and 608 million by the year 2020. The bulk of this material will have to be produced by the timberlands of the Puget Sound Area.

WATER REQUIREMENTS

Projected water needs for the growing, harvesting, and processing of timber products are closely linked to the level of development of the industry and to the level of management practiced on the forest lands of the Area. As a result, the water requirements outlined in this section are based upon the development levels discussed in the following chapter. Any significant changes in development will result in comparative changes in water requirements.

Forest Land Management

A determination of the future water requirements for the growing of timber products is a highly nebulous subject. Many of the proposed timber culture practices involve the use of water, yet the amount of water required for optimum response is largely unknown. In addition, the long-term economic feasibility of the practices themselves are, in many cases, open to question; however, the projected National demand for wood products is such that it appears imperative that per acre yeilds from forest lands be increased. More intensive culture of forest crops, including fertilization and irrigation may be required to keep food supplies in balance with requirements.

Perhaps the greatest potential for water use lies in the field of forest land irrigation. Currently, very little is known of the physical response of forests to irrigation; consequently, the long-term economic feasibility of the practice is in doubt. Yet, there is a great potential for increasing the yield of timber products from lands that are known to be water deficient during the summer months. Based solely on topographic limitations and soil suitability, there are an estimated 635,000 acres[3] of forest land in the Puget Sound Area that might reasonably be expected to benefit from irrigation. These lands are all 0-15% in slope and contain coarse, granular soils that generally

[1] Data taken from the Forest Service report "Prospective Timber Supplies and Forest Industrial Development in the Puget Sound Basin," Wall, 1966, and from preliminary projections developed by the Forest Service Pacific Northwest Forest and Range Experiment Station for the Columbia North Pacific Region.

[2] Estimates derived from applying National per capita consumption figures from Table 3-13 to projected population in the Puget Sound Area.

[3] Based on data obtained from the USDA—Soil Conservation Service

suffer excessive drainage and subsequent seasonal moisture deficiency.

Currently, irrigation is considered feasible only on lands devoted to forest nurseries or seed production areas. There are 1,500 acres of such lands in the Puget Sound Area which will require an estimated 4,950 acre feet of water annually for irrigation purposes. By applying this rate of water use to the other potentially irrigable land, it is evident that irrigation requirements could reach 2,096,000 acre feet annually. This estimate is based on fragmentary information and is therefore useful only in showing the magnitude of water use that might occur from the irrigation of forest lands, should the practice prove feasible.

Current water use for other purposes, such as fire control, engineering or other timber-related administrative needs are minor, probably not exceeding 200 acre feet annually in the Puget Sound Area. Water use for these purposes is not expected to exceed 2000 acre feet by the year 2020.

Forest Products Industries

The consumptive water requirements of the forest products industries are developed in detail in Appendix VI, Municipal and Industrial Water Supply. In summary, the forest products industries will remain the major industrial user of water and in 2020, will account for about 50 percent of the total industrial water use. Water requirements at that time are expected to be about 963 thousand gallons daily, or about 709,340 acre-feet annually.

MEASURES FOR SOIL AND WATER PROTECTION AND WATER YIELD IMPROVEMENT

With increasing levels of management for timber production, as well as other uses of forest lands, there will be a proportionate need for increasing the level of protection to soil and water values. Protection measures range from general management programs through specific project practices. Currently, there is little basis for projecting the types of measures that may be required since much of the basic information necessary in making such an inventory is not available. Many of the current and short-range needs as now visualized, are discussed in Appendix XIV, Watershed Management.

Basic needs for the development of management programs and the implementation of project developments include:

(1) The establishment of goals for water production on national and regional levels, and particularly, for each river basin.

(2) The survey of forested watersheds for determination of hydrologic character. Such information is wholly lacking in many instances.

(3) The continued research of the soil-plant-water relationships of forest land. Currently, information necessary in making management decisions is largely inadequate, often wholly lacking.

When these basic tools are provided, the role of forest land management in water production can be clarified and the needed program or project developments defined with more certainty.

MEANS TO SATISFY NEEDS

In the development of this section it is assumed that the basic management goal of the Area's forests, as well as the forest products industries, will be to provide the volume of wood material and products that were defined in the chapter on Present and Future Needs. This will determine the expected level of development of the forest products industries and to a large extent, the degree of management practiced on commercial forest lands. The data used in this section was drawn from several sources which are identified as they relate to the subject under discussion.

FOREST MANAGEMENT INTENSITY

The raw material supplies needed to sustain the projected industrial development are obtained from three sources; local roundwood production, imports, and utilization of plant residues. Of these, imports and local roundwood production are the key factors, as the use of residues merely involves the better utilization of existing log supplies. The use of residues, however, has the function of reducing the roundwood requirements needed to produce a given volume of the products for which they may be used.

This relationship was recognized in the development of the roundwood requirements outlined in Table 3-16.

Imports, which at present are a key factor in providing adequate raw material supplies, are projected to decrease in the future. In 1962, 38 percent of the roundwood requirements of the Puget Sound Mills was imported from elsewhere in the State of Washington and from British Columbia. It is not expected that this rate will be maintained as a result of increased competition for log supplies in these areas. It is assumed that the amount of material supplied as imports will decline to 35% of the total by 1980, to 30% by the year 2000, and to 25% by the year 2020. On this basis, the projected volume of material obtained from imports is expected to be 212 million cubic feet in 1980, 197 million in 2000, and 149 million in 2020.

The remaining roundwood requirements must be met by local production. In determining whether the goals for local roundwood production can be met, it is necessary to estimate what the yields from local forest lands may be in the future. This is an extremely complex subject, as such an analysis must take into account the productivity of the land; the condition of the forest stands, current and future; the management goals and practices of the landowners; and anticipated changes in the area devoted to the growing of forest products. In the following section, the intensity of forest management required to develop the necessary future wood requirements is developed. It is shown that yields under continuation of existing trends are not adequate to provide the wood needs and that a relatively high level of forest management will be required if the projected production goals of the area are to be realized.

Theoretical Yield

The Forest Service report "Timber Trends in Western Oregon and Western Washington", 1963, provides the basic procedure used in estimating theoretical yields. Briefly, this procedure involves three steps: (1) The classification of forest lands into type-site classes by ownership, which provides a measure of productive potential; (2) a determination of the economical yield per acre under differing levels of management and production goals; and (3) the translation of this data into total annual yields based on expected changes in land use and ownership[1].

[1] Only the highlights of the procedure are presented here. For more detail, the referenced Forest Service report should be consulted.

Type-Site Classification: The type-site classification involves the subdivision of commercial forest lands into five groups based on forest type and site class. Type-site I includes Douglas-fir, western hemlock, Sitka spruce and western red cedar on Douglas-fir sites I and II. Type-site II includes the same species group on Douglas-fir site III. Type-site III includes the same species group on Douglas-fir sites IV and V. Type-site IV includes all other coniferous species, notably the high-elevation types, on all sites. Type-site V includes hardwood forests on all sites.

The current and projected type-site classification is presented in Table 3-17 along with current and anticipated changes in ownership. Beginning at that point, type-site V is not carried as a separate entry, but is allocated to the other four classes. Such allocation is required due to a lack of staisfactory hardwood yield data. In this manner, hardwood growth is allowed for in the calculation of theoretical yield.

Changes in the Forest Land Base: The amount of wood that can be grown in the Puget Sound Area depends, to a large extent, on the area of land devoted to timber growing. Yet, there is every reason to expect that the conversion or reservation of forest lands to other uses will continue, although possibly to a lesser extent than it has in the past. Forest land diversion will occur through needs for recreation; urban-industrial expansion; road, reservoir, or power line development; and the holding of land for private, aesthetic enjoyment. The current situation plus anticipated changes in land use is tabulated in Table 3-17.

Forest land reservations for recreation will range from large withdrawals, such as parks or wilderness units, to small areas needed for campgrounds, picnic grounds, or like developments. The recent enactment of Public Law 90-544 establishing the North Cascades National Park is an example of the former. This park was included in the recommendations of the North Cascade Mountains Study in 1965. If the remaining units proposed by this study are established, the result will be a reduction of 82,600 acres of commercial forest land in the Skagit Basin and an increase of 50,800 acres in the Snohomish and Puyallup Basins. The net change for the Puget Sound Area is a reduction of 31,800 acres of commercial forest land. It is assumed that no further large withdrawals of this type will be made and that additional recreation requirements can be handled on an acre-for-acre reallocation of land.

TABLE 3-17. Commercial forest land in the Puget Sound Area, by owner and type-site class, 1968-2020 (In thousand acres)

Type-site Class	PRIVATE HOLDINGS Large	Medium	Small	PUBLIC HOLDINGS Nat. For.	Oth. Fed.	Other	TOTAL
1968							
1	544.1	8.0	395.8	137.1	4.0	212.7	1,301.7
2	330.1	7.0	486.8	328.1	19.1	163.8	1,334.9
3	203.1	12.0	374.9	444.1	56.8	195.8	1,286.7
4	21.0	1.0	10.0	371.2	36.0	66.9	506.1
5	131.0	5.0	340.9	14.0	12.1	71.9	574.9
ALL	1,229.3	33.0	1,608.4	1,294.5	128.0	711.1	5,004.3
1980							
1	557.6	8.0	336.9	132.3	3.9	209.6	1,248.3
2	338.3	7.0	414.3	316.7	18.5	161.5	1,256.3
3	208.1	12.0	319.1	438.5	55.1	192.9	1,225.7
4	21.5	1.0	8.5	367.7	35.0	65.9	499.6
5	134.2	5.0	290.1	13.5	11.8	70.9	525.5
ALL	1,259.7	33.0	1,368.9	1,268.7	124.3	700.8	4,755.4
2000							
1	590.6	7.9	251.6	130.3	3.8	206.3	1,190.5
2	358.3	6.9	309.5	311.7	18.3	158.8	1,163.5
3	220.5	11.9	238.3	431.5	54.4	189.8	1,146.4
4	22.8	1.0	6.4	361.9	34.5	64.9	491.5
5	142.2	4.9	216.7	13.3	11.6	69.7	458.4
ALL	1,334.4	32.6	1,022.5	1,248.7	122.6	689.5	4,450.3
2020							
1	601.9	7.7	181.8	128.3	3.8	202.5	1,126.0
2	365.2	6.7	223.6	307.1	18.0	155.9	1,076.5
3	224.7	11.6	172.2	425.1	53.6	186.3	1,073.5
4	23.2	1.0	4.6	356.6	34.0	63.7	483.1
5	144.9	4.8	156.6	13.1	11.4	68.5	399.3
ALL	1,359.9	31.8	738.8	1,230.2	120.8	676.9	4,158.4

Reductions of commercial forest land for campgrounds, or like developments, are estimated at 36,000 acres by the year 2020.[1] These reductions will occur throughout the Puget Sound Area. It is assumed that other recreation needs in areas devoted to multiple-use management will not seriously affect timber production levels.

The development of road systems will divert a substantial acreage of commercial forest land. Major highways or thoroughfares, exclusive of the east-west routes, will not detract materially from the total since these routes are located mainly outside the commercial forest zone. Most of the area taken up by roads will be due to the development of road systems needed for the intensive management of forest lands. Assuming that a high level of management will require approximately one mile of road per 120 acres of land,[2] an estimated 138,500 acres of commercial forest land will be diverted for this purpose by 2020.

Forest land conversion or reservation due to urban and industrial expansion is expected to total 252,000 acres by the year 2020[3]. The impact of these land uses will be felt around the periphery of the existing population centers and will mainly affect the smaller private owners of forest land.

[1] Estimate developed with the assistance of the Recreation Committee, PS&AW'.

[2] From "Forest Resources, Private Enterprise, and the Future", Industrial Forestry Association, Worell, 1967.

[3] Data from the Land Usage Development Committee PS&AW.

Other developments, including reservoirs and power lines, are expected to have a limited effect on commercial forest land in the Puget Sound Area. Transmission lines, exclusive of the major east-west corridors, will be mainly located outside the commercial forest zone. Reservoir development will affect some lands in the lowland areas, but there is a limited potential for the inundation of large areas of commercial forest land. It is assumed that no more than 10,000 acres will be diverted for these purposes by 2020.

The final category involves the holding of commercial forest land for aesthetic or personal values other than the production of timber. This form of diversion is almost wholly within the small, private ownerships. The use of forest lands for summer and weekend homes, private resorts, or similar developments is expected to be the most pronounced in the West Sound Basin and in the Whidbey, Camano, and San Juan Islands. It is estimated that this form of diversion will account for 395,000 acres of forest land by 2020.

Changes in Ownership: There appears to be little opportunity for extensive shifts in forest land ownership. The forest industries in the Puget Sound Area were established relatively early compared to other sections of the West, with the result that the ownership pattern has become relatively firm. Public ownerships particularly, are expected to remain largely unchanged. There is considerable opportunity for land exchanges between public and private owners in certain areas; however, these are expected to be on an acre-for-acre basis with little net change in area.

The general shift of ownership from the smaller to the larger private forest land holdings has already occured to a large extent in the Puget Sound Area. Medium-sized ownerships particularly, now constitute less than 10% of the private forest land. Any further increases in the large holdings are expected to come from the small nonfarm tracts. These shifts are not expected to be greater than 50,000 acres by the year 2020.

Economical Yield Under Various Management Levels: A determination of timber yields under varying levels of management is probably the most difficult and theoretical aspect of this analysis. Factors to consider include production goals, probable rotation ages, probable costs and revenues, or similar management factor, for each major category of ownership. The Forest Service has conducted an exhaustive analysis of these factors and has developed estimates of net per acre yields that may be realized under differing levels of management. First, the forest land owners were classified into three broad management categories—conservative, intermediate, and exploitative. In this classification a conservative owner is considered to have long-term management goals and is willing to make comparatively large per acre investments in forest land improvements. At the same time, he is willing to forego immediate yields from his lands for the promise of greater yields at a later date. An exploitative owner, by contrast, does not have comparable long-term goals and emphasizes current or short-term yields at a minimum of investment. Intermediate owners, of course, fall between the other two categories discussed. In order to translate the various ownerships into these three categories, the Forest Service has utilized the percentages indicated in Table 3-18.

TABLE 3-18. Estimated forest land ownership by management group (Expressed as a percentage of the total for each class)

Owner Group	Conservative	Intermediate	Exploitative
Large Private	85	15	--
Medium Private	20	70	10
Small Private	10	30	60
National Forest	100	--	--
Other Federal	85	15	--
Other Public	60	40	--

The second step in the Forest Service procedure was to estimate the economically feasible per acre yield for each management group utilizing a specific set of assumptions regarding revenues and costs. This is done for both sawlog (generally the current goal) and total wood objectives. As an example, the conservative group is expected to initiate management programs for continuous wood production. An even-aged silvicultural system is to be followed with light intermediate cuttings beginning early in the life of each stand and continuing frequently enough to permit high utilization of the site. After the final harvest cut, prompt regeneration of a good quality stand is to be assured by whatever means are necessary. The forest is to be managed under close professional supervision. It is to be provided with an adequate road network or equivalent means of access. All trees six inches and larger, diameter breast-height, are to be utilized to a four inch top; and losses from fire or other causes will be

held to a negligible level. Neither fertilization nor irrigation will be practiced. Value growth arising from conversion and regeneration cost differentials will amount to one percent annually, but there will be no other trend in unit value to affect this growth. The prospective value will be $40.00 (1957-59 basis) per thousand board feet. Similar evaluations were made for each of the other two management groups.

On the basis of these assumptions, estimates of the per acre yields were made. These are tabulated in Table 3-19.

Determination of Theoretical Yield: On the basis of data developed in the preceding paragraphs, estimates of total yield for the Puget Sound Area may now be derived. The first step involves the conversion of the ownership data in Table 3-17 to the three management groups. The percentages given in Table 3-18 are used for this purpose. The results are given in Table 3-20. By applying the data in Table 3-20 to the per acre yields given in Table 3-19, it is possible to estimate the total annual yield for the Puget Sound Area under a sawlog objective or a total wood objective. These figures are summarized in Table 3-21.

TABLE 3-19. Estimated net annual per acre yield under a thinning regime, by owner class, product objective, and forest type-site class (In cubic feet)

Forest Type-Site Class	Saw Log Objective: Saw Logs	Saw Log Objective: Other Wood	Wood Objective
Conservative Owners			
1	129	21	191
2	89	17	153
3	46	13	102
4	33	13	85
Intermediate Owners			
1	104	21	162
2	62	17	132
3	33	13	85
4	25	13	68
Exploitative Owners			
1	66	16	120
2	35	12	92
3	16	8	52
4	11	8	44

TABLE 3-20. Projected forest land acreage in the Puget Sound Area by management group, 1980-2020. (In thousand acres)

Forest Type-Site Class	MANAGEMENT GROUP: Conservative	Intermediate	Exploitative	Total
1980				
1	806.1	304.7	246.6	1,357.4
2	910.5	353.0	380.2	1,643.7
3	840.8	221.2	192.7	1,254.7
4	460.7	33.7	5.2	499.6
ALL	3,018.1	912.6	824.7	4,755.4
2000				
1	820.7	277.2	184.4	1,282.3
2	909.0	307.2	284.3	1,500.5
3	834.3	197.5	144.2	1.176.0
4	454.6	32.9	4.0	491.5
ALL	3,018.6	814.8	616.9	4,450.3
2020				
1	817.6	251.9	133.4	1,202.9
2	896.1	267.4	205.7	1,369.2
3	822.0	176.7	104.5	1,103.2
4	448.2	32.0	2.9	483.1
ALL	2,983.9	728.0	446.5	4,158.4

TABLE 3-21. Projected total annual yield for the Puget Sound Area, by owner class and product objective, 1980-2020 (million cubic feet)

SAWLOG OBJECTIVE					WOOD OBJECTIVE			
Conservative Owners	Intermediate Owners	Exploitative Owners	Total		Conservative Owners	Intermediate Owners	Exploitative Owners	Total
				1980				
288.2	77.4	42.8	408.4		418.3	117.5	74.8	610.6
				2000				
289.6	69.1	32.1	390.8		419.6	104.5	56.0	580.1
				2020				
286.6	61.9	23.1	371.6		415.2	93.3	40.4	548.9

From the above totals, it can be seen there is a substantial difference in total yield depending on product objective. The final step in this analysis is to determine the total yield that might be expected to occur from the probable mix of product objectives. Table 3-22 presents the estimated wood consumption for the two major industrial categories expressed as a percent of the total. It is assumed that the forest land owners will manage their properties for production of the products in demand. For example, in 2020, it is assumed that about 65% of the forest land will be managed on a sawlog objective and 35% on a wood fiber objective. By this method of weighting, the theoretical yield for the Puget Sound Area is estimated at 453 million cubic feet in 1980, 448 million in 2000, and 434 million by the year 2020.

TABLE 3-22. Projected wood consumption, in percent, for the Puget Sound Area, 1980-2020

	Lumber and Wood Products	Pulp and Paper
1980	78%	22%
2000	70%	30%
2020	65%	35%

The estimate of theoretical yield is useful in determining what the productive potential of the Puget Sound Area may be in the long run. It is not particularly useful for short-run predictions since the procedure assumes a higher level of management than now exists throughout most of the area. The utilization of thinnings and salvage of mortality, for example, are projected as occuring at a greater rate than is now commonly done. The analysis also assumes a reasonable regulation of age-classes in the forest stands and the prior development of an access system, neither of which now exists throughout the Area. On the other hand, the procedure does not consider potential yield increases that may be obtained from certain cultural practices, such as forest land irrigation, drainage, or fertilization. The widespread application of these measures, singly or in conjunction, could materially increase the yield from the lands so treated.

Yield Based on Existing Conditions and Trends.

The estimate of theoretical yield is useful mainly in describing the year 2020, by which time it is assumed that most of the management measures described will have been realized. It is evident, however, that the yield during the transition period will not meet projected levels. The report "Timber Trends in Western Oregon and Western Washington", discusses these transitory yields in detail. It takes existing conditions into account, plus anticipated changes in inventory, progress toward stand regulation, or the utilization of thinnings; based on the broad assumption that **present trends will continue.** This data, adapted to fit the land base of the Puget Sound Area indicates a yield of about 345 million cubic feet by 1980, 386 million cubic feet by 2000, and 408 million by 2020.

Conclusions—It is now possible to compare the results of these analyses as presented in Table 3-23.

The potential yield from the Area's forest lands were projected on two bases; (1) the theoretical yield under a moderately high level of management and (2) the probable yield which would result from the continuance of existing trends which expresses a much more gradual drift toward higher management

levels. It is evident from the data of Table 3-23 that the roundwood production goal for the Puget Sound Area cannot be met simply by a continuation of existing trends. Differences will have to be supplied from some other source—such as imports, if not, the total roundwood demand simply will not be satisfied, in which case, the industrial establishment will have to scale its operations down to the available log supply.

Conversely, Table 3-23 data suggests that the Puget Sound Area does have the productive potential to meet local roundwood production goals, but only under a much higher level of management than is now practiced. The introduction of thinning regimes, particularly, is of considerable importance in utilizing material which would otherwise be lost. This, of course, depends to a large extent on access development which should be provided at the earliest practicable date. In addition, cultural measures, including forest land irrigation or fertilization, may be needed. Whatever management measures may be required for a particular tract of land, it is evident that they should be introduced in the relatively near future, if the production goals of later years are to be realized.

TABLE 3-23. Summary of roundwood supply and demand for the Puget Sound Area, 1980-2020 (Million cubic feet)

	ROUNDWOOD SUPPLY				
Period	Total Roundwood Demand	Imports	Local Production (Goals)	Theoretical yield	Yield from projection of existing condition
1980	606	212	394	453	345
2000	655	197	458	448	386
2020	596	149	447	434	408

WATER-SOIL PROTECTION AND WATER YIELD IMPROVEMENT

The intensification of management for timber production will also require intensification of soil and water protection measures. The development of widespread road systems combined with intensive thinning practices and more frequent harvest cuts will greatly increase the potential for soil erosion and other factors which result in a deterioration of water quality. The means for providing the necessary

PHOTO 3-16. Thinning in commercial forest stands for yield improvement, Deschutes Basin (State of Washington photo).

protection vary widely depending upon soil type, structure and stability, topography, cover type and condition, precipitation, and the type of land-use activity involved. Specific protection measures, as now visualized, are discussed in Appendix XIV, Watershed Management. These are summarized below.

1. The intensification of research and studies aimed at defining the hydrologic character and soil-plant-water relationships of forest lands. Such infomation will provide forest land managers with guide lines to enable development of adequate management programs and practices and will help define the project measures needed for soil and water protection.

2. The adequate reconnaissance of undeveloped forest lands to identify potential problem areas. Such information will aid advance planning in the proper location of roads and timber cutting areas.

3. The continuation of practices which are known to be effective in the control of erosion and the maintenance of water quality. Adherence to adequate standards in road construction; selection of logging methods least disruptive to the soil and cover; and the limitation of type, size, and use of equipment, are examples of these measures.

4. The continued development of logging techniques and equipment that are less disruptive of the soil and ground cover. Recent accomplishments in this field include the balloon-logging system and the development of small, highly mobile yarding equipment. Industrial acceptance and participation in the development of these measures should be greatly encouraged.

5. The intensification of technical assistance through Federal, State, and private cooperative programs to the small private forest land owner. The expansion of information and education programs to obtain general acceptance of progressive management programs with the general public.

Data obtained from experimental trials throughout the Nation indicate that there is a considerable potential for improving the water yield from forested areas. Experiments in snowpack management and in cover-type conversion or manipulation show that these measures can affect the timing or period of runoff and, in some cases, the amount of useable water produced. Any programs for water yield improvement must await the establishment of goals for water production in any given river drainage. These would clarify the role to be played by forested watersheds and, to some extent, define the types of measures that may be required. Research is again the key in developing effective management programs or project proposals.

DEVELOPMENT OF THE FOREST PRODUCTS INDUSTRIES

The development of the forest products industries in the future is dependent primarily on two factors; the demand for the types of products available in the Area and the raw material supply available for their production. In the development of this section, it is assumed that the primary goal of the industry will be to produce the volume of wood products described in the section on Present and Future Needs. It is also assumed that adequate raw material supplies will be available for this purpose.

Production

The production estimates for the various industrial categories are given in terms of cubic feet and are essentially the same figure used in describing wood consumption for each industry. Strictly speaking, this is not correct. The volume of products obtained from a given volume of raw material will vary depending on the manufacturing process involved. In other words, a thousand board feet of logs would produce more or less than a thousand board feet of products (were they measured on this basis) depending on whether they were sawn into lumber, or pulped from the production of paper. In order to convert consumption figures into the several units of measure used to describe product output, it would be necessary to make numerous assumptions regarding plant size and efficiency, manufacturing process, raw material size and possible changes in technology. It is felt that such a procedure would have indefinite results and that consumption figures would be equally effective in describing the expected industrial trends.

In the projections of wood consumption for the Puget Sound Area, it was assumed that the relative distribution of the various manufacturing processes among the economic sectors would not change materially from the 1963 base. Trends toward increasing utilization of small logs, decreasing mortality, and changes in volume and use of residues were also considered in projecting future wood consumption to the year 2020.

Lumber: Wood consumption for the lumber industry is expected to drop about 23% to 178 million cubic feet by 1980; rise to 185 million by 2000; and drop again to 155 million by the year 2020. In 2020, the central sector is expected to consume some 71% of the total, about 111 million cubic feet. The west sector is expected to rank second with 32 million cubic feet, followed by the north sector with 12 million cubic feet. Actually lumber production is expected to be somewhat lower than the consumption figures due to increased use of smaller logs.

Plywood and Veneer: By the year 2000, national veneer log consumption is expected to nearly triple, whereas the Area's consumption will only double. Like the rest of the Pacific Northwest, the Puget Sound Area's veneer and plywood industry is not expected to grow quite as rapidly as national demand because of the development of the softwood veneer and plywood industry in the South.

Veneer log consumption in the Puget Sound Area is expected to be 122 million cubic feet in 1980, 156 million in 2000, and 179 million in 2020. The central sector is expected to be the greatest consumer in 2020 with 109 million cubic feet, followed by the west sector with 40 million and the north sector with 30 million.

Pulp and Paper: Consumption of pulpwood in the Puget Sound Area is expected to increase more than the national average. The proximity of sawmills, plywood plants and pulpmills to each other in the Area has made mill residues a relatively low cost raw material for the pulp industry. The waters of Puget Sound have made it feasible to transport large volumes of residues to the pulpmills at low cost. An example of such movement is the transporting of chips from British Columbia to Tacoma. Mill residues also move long distances by truck and rail to the Puget Sound Area. Chip movements from Libby, Montana, to Tacoma is an example of this type of residue transportation.

Estimated consumption of wood fiber by the pulp and paper industry is expected to increase to 342 million cubic feet by 1980, 499 million cubic feet by 2000, and 546 million by the year 2020. Again, the central sector will account for the most by 2020, 55% or 301 million cubic feet. The west sector is expected to consume 180 million cubic feet, followed by the north sector with 65 million.

Miscellaneous Wood Products: The national projections show that little increase is expected in the use of miscellaneous wood products such as poles, piling, fenceposts, or fuelwood. The projections for the Puget Sound Area follow these national trends; however, the miscellaneous wood products category, in this report, includes log exports. Exports are expected to fluctuate widely with changes in international economic conditions or trade agreements, therefore the consumption figures reflect the Area's expected response to international demand for roundwood.

Wood consumption in the miscellaneous wood products industries is expected to rise better than 200%, to 172 million cubic feet by 1980, and then generally decline to 116 million cubic feet by 2000, and to 51 million cubic feet by 2020. The Central Sector is again the largest consumer with 31 million cubic feet in 2020, followed by the West Sector with 12 million and the North Sector with 8 million.

Employment

Forest industry employment has been projected for the period 1963-2020 for each of the major industrial groups (Table 3-24). Employment generated by the export of logs has been added to the miscellaneous wood products category. With the exception of export employment, data are based on statistics which include only those workers directly employed by wood-using industries reported by the Employment Security Department as covered employment. Employment in service or support industries was not included.

The productivity of workers in the forest industry has been increasing due to automation and mechanization, resulting in a reduced employment per unit of production. It is expected that productivity will continue to increase in the future, although at a slower rate. Employment projections for the Puget Sound Area were made by applying productivity trends for specific industries to the estimates of their log consumption for the study period.

The changes in forest product manufacturing brought about by changes in effective demand and raw material supply, plus changes in worker productivity, will cause total forest industry employment to decline 30% between 1963 and 2020. In 1963, employment in the forest product industries was 31,100 workers, including export employment. Employment is expected to gradually decline to 27,300 workers by 1980, 25,600 by the year 2000, and to 21,900 by 2020.

Lumber and Wood Products Industries: This lumber and wood products industry (SIC 24, plus exporting) accounts for the general decline in employment. Every category within this industry is projected to have reduced employment in the future. The total employment for this category in 1963 was 21,500 workers, which is projected to drop to 12,600 workers by 2020. Sawmill and planing mill employment will drop the most, 80% or 5,200 persons. The next largest decrease is expected to be in logging industries, 47% or 2,100 persons. Employment in veneer and plywood plants will be lower by 1,600 persons (26%) in the year 2020. Employment in other lumber and wood products plants is expected to remain about the same as it was in 1963.

Paper and Allied Products Industries: Employment in the paper and allied products industries (SIC 26) is expected to increase between 1963 and 1990,

TABLE 3-24. **Current and projected average annual employment in the Puget Sound Area, by industry, and sector, 1965-2020**

Sector and Year	Total	Logging SIC 2411	Sawmills and Planing Mills SIC 2421	Veneer and Plywood Plants SIC 2432	Miscellaneous Lumber and Wood Products SIC 24 Except 2411, 2421, 2432	Paper and Allied Products AIC 26
ALL SECTORS:						
1965	31,300	4,500	6,500	6,100	4,400	9,800
1970	27,900	4,200	4,500	5,400	4,400	9,400
1980	27,300	3,900	3,100	5,600	4,400	10,300
1990	26,900	3,500	2,100	5,100	4,400	11,800
2000	25,600	3,200	2,100	5,000	4,400	10,900
2010	23,800	2,500	1,800	4,800	4,400	10,300
2020	21,900	2,400	1,300	4,500	4,400	9,300
NORTH:						
1965	4,200	900	600	1,000	600	1,100
1970	3,900	900	400	900	600	1,100
1980	3,900	900	300	900	600	1,200
1990	3,800	700	200	900	600	1,400
2000	3,600	700	200	800	600	1,300
2010	3,400	600	100	800	600	1,300
2020	3,000	500	100	700	600	1,100
CENTRAL:						
1965	19,200	2,800	4,600	3,700	2,700	5,400
1970	17,000	2,600	3,200	3,300	2,700	5,200
1980	16,400	2,400	2,200	3,400	2,700	5,700
1990	16,000	2,200	1,500	3,100	2,700	6,500
2000	15,300	2,000	1,500	3,100	2,700	6,000
2010	14,100	1,500	1,300	3,000	2,700	5,600
2020	13,000	1,500	900	2,800	2,700	5,100
WEST:						
1965	7,900	800	1,300	1,400	1,100	3,300
1970	7,000	700	900	1,200	1,100	3,100
1980	7,000	600	600	1,300	1,100	3,400
1990	7,100	600	400	1,100	1,100	3,900
2000	6,700	500	400	1,200	1,000	3,600
2010	6,300	400	400	1,000	1,100	3,400
2020	5,900	400	300	1,000	1,100	3,100

then gradually decline through 2020. In 1963, employment for this category was 9,600 workers. This is expected to increase to 10,300 by 1980, and to 10,900 by the year 2000. Employment in 2020 is expected to be 9,300 persons.

Distribution Within Economic Sectors: All three economic sectors will have a decrease in the proportion of workers in logging, sawmills and planing mills, and veneer and plywood plants. The north and central sectors will have a slight increase in the proportion of workers in the miscellaneous wood products category, whereas the west sector is expected to remain unchanged. All three sectors will have large increases in the paper and allied products industry. These trends are based in part on the assumption that the relative distribution of industry groups among the sectors will remain essentially constant during the projection period. The assumed distribution is given in Table 3-25.

The central sector will continue to be the most important segment of the Area's forest economy in 2020. This sector will have the largest employment,

TABLE 3-25. Distribution of employees within sectors by industry groups, 1963 and 2020 (In percent)

Industry Group	North Sector 1963	North Sector 2020	Central Sector 1963	Central Sector 2020	West Sector 1963	West Sector 2020
Logging	15	11	10	7	6	4
Sawmills & Planing mills	15	5	25	10	18	6
Veneer & Plywood Plants	24	16	20	14	18	10
Miscellaneous Wood Products Plants	19	21	18	19	17	17
Paper & Allied Products Plants	27	47	27	50	41	63
TOTAL	100	100	100	100	100	100

half of which will be in the paper and allied products industry. The central sector will generate more value added by manufacturing than either of the other sectors.

The increasing importance of the paper and allied products industry in the Puget Sound Area, along with advanced manufacturing, marketing, and management techniques by the other industries, means that the forest economy of the Area will tend to become more stable over time. In part, this reflects an assured timber supply stemming from the trend of forest management policies on both public and private forest lands in Western Washington.

SUMMARY AND CONCLUSION

PRESENT STATUS

The Puget Sound Area, like the remainder of the Douglas-fir Region of western Oregon and western Washington, contains some of the most productive forest land of any region in North America. These lands are of considerable importance locally and nationally.

The Puget Sound Area is predominantly forest covered with some 76% of the total land area classified as forest land. About 78%, or 5,024,600 acres, of the forest area is considered capable of producing continuous crops of industrial wood.

Hydrologically, the Area's forest lands are of prime importance. All of the Area's major rivers and the majority of the smaller streams flow from forested watersheds which provide over 80% of the total surface water supply. The condition of these watersheds materially affects the quality and quantity of water produced, as well as the timing of water flows. The development and use of forest lands for timber production, or other forest uses, needs to be carefully controlled to maintain the hydrologic regimen. For the most part, these factors have not received adequate attention in the past.

The Puget Sound Area currently supports a highly developed and diversified forest products industry. The industry supplies virtually all of the Area's demand for softwood products and a substantial portion of the national demand as well. Industrial establishments are found throughout all eleven basins in the Puget Sound Area and are the major source of economic activity in many of the smaller communities. Collectively, the industry ranks second in total input to the Area's economy, exceeded only by aerospace.

The forest products industries are a major consumptive user of water, accounting for over 70% of the total industrial water use. In addition, water is used in many non-consumptive ways, as in the transportation, handling, washing, and debarking of logs. The forest products industries are also a major source of industrial water and air pollution. Pulp mill effluents particularly, are a source of concern in several fresh and salt water areas.

CURRENT AND FUTURE NEEDS

National projections indicate a large increase in the demand for wood products by the year 2020, most of which is expected to be supplied by domestic production. The Puget Sound Area, by virtue of its highly productive forest land and existing industrial base, is expected to supply a significant portion of the wood products requirements. Total demand is expected to rise by 44% by the year 2020.

While specific goals governing water production from forest lands, or pollution abatement from industrial operations have not been established, there is a clear need for the further development of both. Future water requirements for municipal and industrial use, as well as non-consumptive uses such as recreation, irrigation, or power production, makes it

imperative that water yields from forest lands be maintained at least at existing levels of quantity and quality. There is every reason to believe that measures for the improvement of existing water yields, both from the manipulation of watershed areas and from pollution abatement, would be welcomed.

MEANS TO SATISFY NEEDS

The raw material requirements for the forest products industries will be met in three ways—by imports, domestic roundwood (log) production and the utilization of plant residues. Imported material and plant residues will provide a significant portion of the raw material needs, yet the greater portion will continue to be supplied by roundwood production om the Area's forest lands. The amount of roundwood produced in the Puget Sound Area in the future depends mainly on three factors—the area devoted to the growing of forest products, the productivity of the land, and the management goals and practices of the landowners.

Diversion of commercial forest land to uses other than timber production is a major cause for concern in the Puget Sound Area. By 2020, it is estimated that 17% of the present commercial forest area will be diverted to other uses. Even under greatly increased management, the remaining forest land base will be very near the minimum required in meeting the Area's roundwood production goals.

Much of the most productive forest land in the Puget Sound Area is now—or is projected to be—diverted for uses other than timber production. Of the remaining land, most is of lower productive ability, particularly that in public ownerships. The remaining high quality timberland is mainly held by large corporate owners. It is important that this timberland base be retained to the extent possible.

In order to meet the expected demand for wood products throughout the nation, it is imperative that most of the commercial forest land be managed intensively to produce as much wood as it is capable of doing. Unless intensive management of the forests is deliberately encouraged, the land is not likely to produce enough raw material in the long run to permanently support manufacturing employment and income at more than about half their present levels. Such an acceleration of intensive management will require that the landowners be encouraged and not discouraged from practicing better forestry. Economic incentives are most important for the private landowners and it is essential that nothing be done to reduce or destroy these incentives.

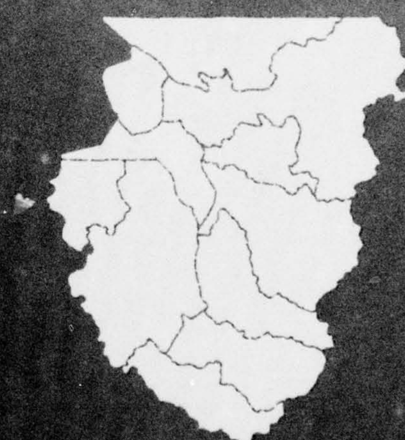
The public forest lands have an essential role to play in supporting the Area's forest products industries now and in the future. The development of management programs and production goals on these lands are, for the most part, adequate, but current funding levels are not sufficient to meet early development needs. The primary block to intensive management at the present time is a lack of roads. It is desirable to expand these road networks as rapidly as possible through public appropriations.

The large corporate owners of forest lands are highly capable of practicing intensive management and have often led the way in the improvement of forestry practices. No specific actions to encourage these owners appear necessary; however, future changes which might serve to discourage them should be avoided.

Small and medium forest landholdings in the Puget Sound Area have a potential for improved timber production, but in most cases will not be intensively managed. Steps to assure prompt and effective reforestation after harvest will probably accomplish more to increase yields on these lands than anything else. Again, changes to discourage timber production on these lands should be avoided, paparticularly with regard to taxation.

The intensive management of forest lands for timber production, or any other compatible use such as recreation, fish and wildlife, or forage production, will require the use of adequate measures to protect the watershed quality of the lands involved. Water production is itself a major use of forest land. Measures expressly designed to improve existing water flows from these lands may be—and probably will be—required in the future. This will require the continuation of practices currently known to be effective in controlling water flows as well as extensive research for the development of better techniques.

Part Four
Mineral Resources
Puget Sound Area



PART FOUR—MINERAL RESOURCES PUGET SOUND AREA

KNOWN AND POTENTIAL MINERALIZED AREAS

During 1964, the Puget Sound drainage area accounted for about 44 percent of Washington's mineral production. King, Pierce, Skagit, Snohomish, and Whatcom were and still are the leading counties in terms of quantity and value of minerals produced. Total production value from the whole area was $35.6 million in 1964.

The Puget Sound Area is particularly rich in reserves of nonmetallic minerals. Sand, gravel, clay, cement, and stone are produced in quantity for the construction industry. The largest olivine deposit in the United States is located in the Area, and several operators are presently producing from it. All of the State's talc production and almost all of the peat production came from the Area. Limestone for use in making cement and lime, and for use as a soil conditioner is plentiful, and the limestone used by two of the State's largest cement plants is quarried in the region. Other nonmetallic minerals that are now being mined, have been mined, or have the potential for production, are strontianite, celestite, silica sand, quartz, alunite, and pozzolanic materials. Substantial reserves of most of these minerals are still available.

In the past, the Area has produced considerable amounts of minerals that have yielded copper, gold, silver, manganese, antimony, arsenic, chrome, iron, lead, mercury, and zinc. During the past two decades production has declined, but with the constant change in requirements for metals brought on by rapidly changing technology, and with improved methods in extractive metallurgy and lower cost mining methods, the Puget Sound Area holds promise as a future major source of metallic minerals. The Area contains several apparently large low-grade copper deposits that could produce copper, with molybdenum, silver, zinc, and gold as by-products.

At the present time, no crude oil or natural gas is produced in the Puget Sound Area, but the Area has a potential for future production. Within the Puget Sound Area there are unexplored areas that have structural and stratigraphic conditions favorable for the accumulation and storage of oil and gas.

Coal reserves in the Puget Sound Area are extensive, but much of this coal is not mineable at economic rates under present technology. The important fields are in Cedar-Green, Puyallup and Nooksack Basins.

In summary, the Puget Sound Area is richly endowed with mineral resources. Extensive coal, sand and gravel, clay, stone, and peat deposits occur in the lowland areas. The mountainous area in the eastern part of the region has a large potential for producing metallic minerals, as well as stone and nonmetallic mineral products.

Areas in which mineral deposits occur in the Puget Sound Area are shown on the map in Figure 4-1. More detailed maps showing mineral resources in each of the basins are shown in Figures 4-3 through 4-13.

MINERALS' ECONOMIC CONTRIBUTION

Purpose

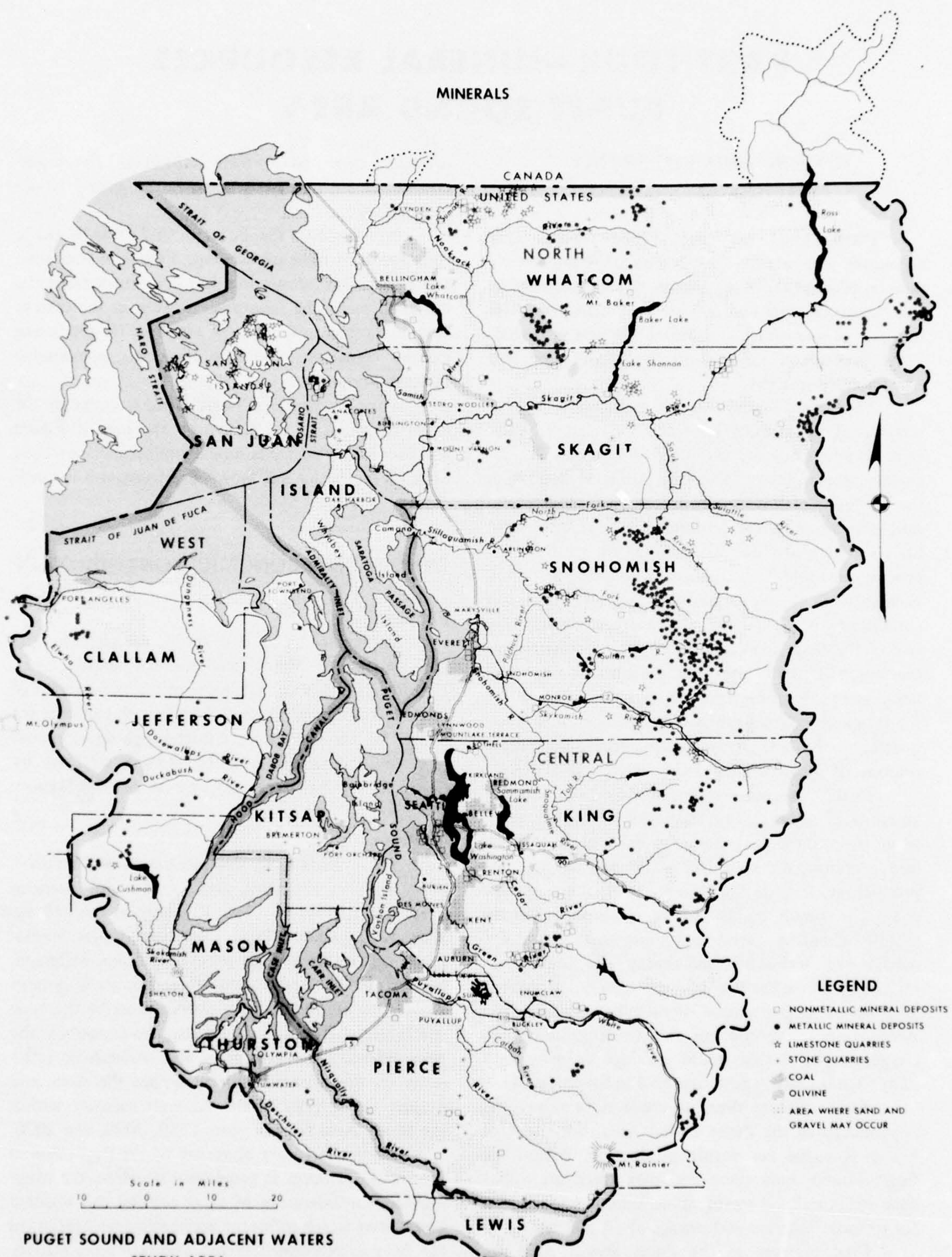
The mineral industry study, prepared by the U.S. Bureau of Mines, and the Washington State Division of Mines and Geology, of the Department of Natural Resources, is intended to furnish guidance for appraising the need for comprehensive development of water and related land resources as set forth by Senate Document 97, 87th Congress, Second Session.

Scope

The mineral study delimits the mineral industry potential of a 12-county area or 11 major basins as shown in Figure 4-1. The 12 counties covered are King, Kitsap, Island, Pierce, San Juan, Skagit, Snohomish, and Whatcom, and parts of Clallam, Jefferson, Mason, and Thurston. Major objectives are to present the record of mineral production, describe the type and location of major mineral resource deposits in the Area, identify the economic and technologic influences on the mineral industry within the Area, and project the activity of the minerals industry within the Study Area for the years 1980, 2000, and 2020.

Since the future economy of the Puget Sound Area will not occur in geographic isolation, the study includes consideration of areas beyond the regional boundaries which influence economic development in the Area of principal interest. The economic activity of the Puget Sound Area is tied to activities in the

MINERALS



PUGET SOUND AND ADJACENT WATERS STUDY AREA

Figure 4-1. Mineral Resources in the Puget Sound Area

Pacific Northwest, the Nation, and other nations because of trading relations and competition. An analysis is made of these interrelationships and their trends and changes as they influence the economic future of the Puget Sound Area.

Physical Features and Their Relationships to Mining

The Puget Sound drainage basin is a U-shaped trough extending east about 110 miles from the Olympic Mountains to the Cascade Mountains divide, and south approximately 140 miles from the Canadian border to the southern tip. It falls within the Puget Sound, Cascade Mountain, and Olympic Mountain physiographic provinces in western Washington. The land area, of about 13,300 square miles, is slightly larger than the states of Delaware and Maryland combined; water area totals about 2,000 square miles. The west slopes of the Cascade Mountains cover the eastern part, and the east slopes of the Olympic Mountains cover the western portion. Lowlands are prominent in the central part from the southern tip to the Canadian border.

Puget Sound itself is an inland sea which joins the Pacific Ocean through the Strait of Juan de Fuca. The Sound, over 90 miles long, extends southward to Olympia. There are over 2,000 miles of coastline in the many inlets and islands of the Sound.

Puget Sound Province

The Puget Sound Province lies between the Olympic Mountains-Willapa Hills area to the west and the Cascade Range to the east. It consists of a lowland area, mostly below 1,000 feet in altitude, that reaches across the State from Canada into Oregon, where the Willamette Valley is its geomorphic continuation. The northern half is partly occupied by the intricate reaches of Puget Sound, Admiralty Inlet, and the Georgia, Juan de Fuca, Rosario, and Haro Straits.

Throughout the Puget Sound Province, the bedrock consists largely of Tertiary sedimentary and volcanic rocks. Much of the southern part of the province is covered by sand and gravel and finer sediments that were sluiced out toward the south by melting glaciers. Alluvium also is common in areas immediately surrounding the Sound. In the northern half of the region, erosion has cut through the sedimentary formations exposing Paleozoic and Mesozoic rocks. Industrial minerals are the most important mineral products mined in the province, however, some metallic minerals have been mined in the Green River and San Juan areas.

Bituminous and subbituminous coal of the Eocene Puget Group and Paleocene Chuckanut Formations occur extensively within the eastern part of the province. Of the eight major coalfields of the State, all but one are in this general area.

Cascade Mountains Province

The many large rivers and their tributaries have dissected the Cascade Mountains Province into deep valleys, canyons, and ravines. The intervening ridges are commonly steep-sided, high, and serrated above the timber line. Glacial features are common in the Cascade Mountain Range.

The rocks in the northern half of the Cascade Mountains Province are chiefly Paleozoic and Mesozoic sedimentary and metamorphic types and granitic rocks. In the central part, rocks are mainly Tertiary volcanics with minor sedimentary interbeds.

HISTORY OF MINING ACTIVITY

Mineral Production Trends

Mineral production values for the Puget Sound Area have ranged from $23.9 million in1955 to $35.5 million in 1964 which is less than 1 percent of national mineral production values, Table 4-1.

Although total mineral production values for the Area cannot be published each year, to avoid disclosing individual company confidential information, the Area in the past decade has accounted for between 36 and 44 percent of the mineral production value in the State. The Puget Sound Area accounted for about 44 percent of the State mineral production value in 1964. Throughout the period 1955-64, five counties have led in terms of mineral production value. The counties, in order of descending value, are King, Whatcom, Pierce, Skagit, and Snohomish. On the average, mineral production value from the other seven counties amounts to less than $500,000 for each county annually and is confined largely to output of common construction materials, such as sand and gravel and stone.

Total recorded mineral production for the Puget Sound Area approximates $751 million, Table 4-2. Although Bureau of Mines records for metals, coal, and cement are complete from early 1900, information before 1933 is sparse for the other nonmetals. Nevertheless, nonmetals have accounted for $527.6 million, or 70 percent of the total

TABLE 4-1. Value of mineral production by county, 1955, 1960, 1964 (thousand dollars)

County	1955	1960	1964	Minerals Produced In 1964 In Order Of Value
Clallam	$ 253	$ 88	$ 231	Sand & gravel, stone.
Island	109	220	72	Stone, sand & gravel.
Jefferson	W	457	W	Stone, sand & gravel.
King	9,151	7,805	12,826	Cement, sand & gravel, stone, coal, clays, peat.
Kitsap	133	282	372	Sand & gravel, stone, peat.
Mason	W	W	234	Stone, sand & gravel.
Pierce	2,502	3,290	4,327	Sand & gravel, lime, stone, clays, peat.
San Juan	W	156	W	Sand & gravel, stone.
Skagit	W	3,053	4,108	Cement, olivine, sand & gravel, stone, soapstone, peat.
Snohomish	1,359	1,938	3,358	Sand & gravel, stone, peat, clays.
Thurston	387	267	347	Sand & gravel, coal, stone, peat.
Whatcom	W	W	W	Cement, stone, sand & gravel, olivine, clays.
Combined counties	10,034	W	9,676	
Puget Sound Area Total	23,928	W	35,551	
State total	67,334	72,404	80,977	
Percent of State total	36	W	44	
National total—million dollars	15,792	18,032	20,472	

W Withheld to avoid disclosing individual company data.

recorded mineral production value. Coal and peat, at \$216.4 million, comprised 29 percent of the total, and metals, at \$7 million, were less than 1 percent of the total recorded value.

Cement, coal, sand and gravel, and stone stand out as dominant materials produced and comprise over 96 percent of the total recorded mineral production values in the Area.

Several commodities, such as clay, lime, silica sands, olivine, talc, copper, gold, and manganese, have contributed significantly to the total minerals value and will possibly share in the future economic contributions to the Area.

Compiling production of minerals by decade, Table 4-3 shows the production of construction materials, such as cement, sand and gravel, and stone, is increasing. Progressive increases also show for lime, olivine, and silica. Output of clays and talc has declined from the 1950-59 base, and coal output shows a continuous decline from the high rates of production established during the period 1910-1919. The reduction of coal output can be attributed to the difficulty of mining the coal as well as a shift to other fuels.

For metals, production of gold was highest during the depression years, copper was mined extensively in the late 1920's and manganese output was greatest during World War II.

Relative unit values of minerals over the period 1900-1964 were computed by dividing actual unit values of select commodities by the Spencer raw material index (29),[3] Table 4-4. Annual raw material prices were aggregated to conform to decade compilations derived from Table 4-3. The computations show that the relative price for many of the nonmetals, such as stone, clay, silica, talc, lime, and olivine, have declined in the past 25 years.

Throughout the 25-year period, the relative unit price for cement increased only 17 cents per barrel, and sand and gravel increased only 6 cents per ton. Coal, in direct contrast to these figures, has increased about \$2.00 per ton over the 25-year period.

Mineral Commodity Reviews

Reviews by commodity for minerals ascertained from past relationships to be important to the growth of the Area appear in the Puget Sound and Adjacent Water Studies "Economic Environment Exhibit D." Also in Exhibit D, trends are given for each commodity where information is available. Relationships such as marketing factors (local, regional and

3 Underlined numbers in parentheses refer to items in the list of references at the end of this chapter.

TABLE 4-2. Mineral production in Puget Sound Area, 1900-64

	Quantity*1 (Thousands)	Value (Thousands)	Minerals Produced Counties	Years of Recorded Production
Nonmetals				
Abrasives	W	W	Pierce, Skagit	1923-43, 1946-47
Asbestos	W	W	Skagit	1930-34
Clay	2,501	$ 2,897	King, Pierce, Skagit, Snohomish, Whatcom	1933-64
Cement (376-lb. barrels)	127,230	319,319	King, Skagit, Whatcom	1909-64
Lime	597	8,791	King, Pierce, San Juan, Snohomish, Whatcom	1925-56, 1963-64
Olivine	W	W	Skagit, Whatcom	1946-64
Pumice	1	2	King, Skagit, Snohomish	1946-52, 1955-56
Sand & gravel	161,275	118,182	All counties	1935-64
Silica sand	492	2,864	King, Pierce, Skagit, Whatcom	1937-64
Stone	45,909	71,935	All counties	1929, 1933, 1937-64
Strontium	W	W	Skagit	1940-42, 1946, 1953, 1956-59
Sulfur	*2	9	King	1939-40, 1943-47, 1950
Talc	93	601	King, Skagit	1933-64
Undistributed*3	109	3,031		
Total nonmetals*4		527,629		
Fuels				
Coal	69,260	214,912	King, Pierce, Skagit, Thurston, Whatcom	1900-64
Peat	306	1,522	King, Kitsap, Pierce, Skagit, Snohomish, Thurston	1957-64
Total fuels*4		216,434		
Metals*5				
Gold (ounces)	107	2,689	Clallam, King, Pierce, Skagit, Snohomish, Whatcom	1904-64
Silver (ounces)	343	230	Clallam, King, Pierce, Skagit, Snohomish, Whatcom	1904-49, 1951-62
Copper	7	2,252	King, Pierce, Skagit, Snohomish, Whatcom	1904-11, 1914-30, 1933-49, 1951-56, 1958-62
Lead-zinc	*2	3	King, Pierce, Skagit, Snohomish, Whatcom	1908, 1910, 1914, 1916, 1918, 1922, 1924-41, 1949, 1951-53, 1961
Chromite	*2	10	Skagit	1917-18, 1956, 1958-59
Iron ore	35	W	Snohomish	1907-10
Manganese (35 percent or more Mn)	52	1,845	Clallam, Mason	1916, 1924-26, 1942-46, 1952-53, 1959
Mercury	W	W	King	1957-58
Molybdenum	3	W	Snohomish	1958-59
Undistributed*6		67		
Total metals*4		7,095		
Mineral industry total*4		751,159		

W Figure withheld to avoid disclosing individual company confidential data.

*1 Short tons unless otherwise specified.

*2 Less than 500 tons.

*3 Value of nonmetal items that cannot be disclosed: abrasives, asbestos, olivine, strontium.

*4 Figures in columns may not add to total because of rounding.

*5 Recoverable content of ores, etc.

*6 Value of metal items that cannot be disclosed: iron ore, mercury, and molybdenum.

TABLE 4-3. Production of minerals in Puget Sound Area by decade[1]

	Nonmetals														
	Cement		Sand & Gravel		Stone		Clay		Silica		Talc		Undistributed*2		
Year	Barrels	Value	Short Tons	Value	Short Tons	Value	Short Tons	Value	Short Tons	Value	Short Tons	Value	Short Tons	Value	
1900-09	519	$ 886	--	--	--	--	--	--	--	--	--	--	--	--	
1910-19	9,417	15,404	--	--	--	--	--	--	--	--	--	--	--	--	
1920-29	17,244	37,208	--	--	28	$ 70	--	--	--	--	--	--	98	$ 1,369	
1930-39	19,656	32,295	6,728	$ 2,921	1,419	2,049	82	$ 99	--	--	2	$ 15	149	1,678	
1940-49	27,966	60,881	29,958	15,728	6,628	9,705	570	606	119	$ 419	24	203	173	2,391	
1950-59	33,035	104,164	71,894	53,227	22,386	36,120	1,309	1,578	209	1,237	52	300	119	2,455	
1960-64	19,393	68,482	52,695	46,306	15,448	23,991	540	614	163	1,208	14	82	167	3,938	
Total*3	127,230	319,319	161,275	118,182	45,909	71,935	2,501	2,897	492	2,864	93	601	706	11,831	

		Fuels					Metals							
	Nonmetals	Coal		Peat		Fuels	Gold		Silver		Copper, Lead, Zinc	Other Metals	Metals	Mineral Industry
Year	Total Value	Short Tons	Value	Short Tons	Value	Total Value	Ounces	Value	Ounces	Value	Value	Value	Total Value	Total Value
1900-09	$ 886	17,148	$ 34,023	--	--	$ 34,023	22	$ 458	120	$ 72	$ 66	$ 52	$ 648	$ 35,557
1910-19	15,404	19,276	49,824	--	--	49,824	19	395	41	33	349	15	793	66,020
1920-29	38,647	14,061	52,359	--	--	52,359	26	542	115	80	1,347	320	2,288	93,294
1930-39	39,058	9,773	29,985	--	--	29,985	37	1,213	27	15	219	--	1,447	70,490
1940-49	89,932	6,786	32,366	--	--	32,366	1	51	33	23	106	1,418	1,598	123,897
1950-59	199,082	1,895	13,592	107	$ 393	13,985	1	22	7	6	130	117	274	213,340
1960-64	144,621	322	2,763	199	1,130	3,892	*4	8	1	1	38	--	47	148,561
Total*3	527,629	69,260	214,912	306	1,522	216,434	107	2,689	343	230	2,255	1,921	7,095	751,159

*1 Quantities and values are thousands.

*2 Includes abrasives, asbestos, lime, olivine, strontium, sulfur.

*3 Columns and rows may not add to totals because of rounding.

*4 Less than 500.

national), technology specifications, processing techniques, substitutions, trends in ore grade, and other important aspects for many commodities are examined. Pertinent information also is given for mineral requirements by the pulp and paper and primary metals industries. Figure 4-2 provides a locational picture of the major mineral producers and related industrial operations in the Puget Sound Area, and shows the relative importance of the mineral industry in each of the economic divisions.

PRESENT AND FUTURE DEMAND FOR MINERALS FOR THE PUGET SOUND AREA

There are numerous problems associated with projecting mineral needs for the Study Area. These problems are greatly magnified when projections are done at the small scale of a river basin. Thus, for simplicity, and for the sake of greater accuracy, projections contained in this portion of the Appendix have been done only at the Study-Area level. Some of the problems that are evident in projecting mineral needs, are data problems associated with mineral production disclosure by individual companies, the small amount of land that is in question, mining activities restricted only to locations of deposits, plus the wide range of problems that are associated with the economic and governmental aspects of mining.

The present and future demand for minerals in the Puget Sound Study Area that have been developed for this portion of the Appendix include water needs, land needs, *future mineral needs*, and a short discussion related to the means to satisfy mineral needs.

If specific information is desired for a mineral location, or detailed information regarding a single mineral, please refer to the Present Status and Potential Section of this chapter, where information and a detailed map of mineral locations can be examined.

TABLE 4-4. Relative unit values of nonmetals and coal from Puget Sound Area by decade, 1900-64[1]

Year	Spencer Raw Material[2] Price Index 1957-59 = 100	Construction Materials: Cement Actual	Cement Relative	Sand & Gravel Actual	Sand & Gravel Relative	Stone Actual	Stone Relative
1900-09	34.1	$1.71	$5.00				
1910-19	40.8	1.64	4.00				
1920-29	69.2	2.16	3.12			$2.50	$3.62
1930-39	52.6	1.64	3.12	$0.43	$0.82	1.44	2.74
1940-49	65.4	2.18	3.33	.53	.81	1.46	2.23
1950-59	93.0	3.15	3.38	.74	.80	1.61	1.73
1960-64	101.0	3.53	3.50	.88	.87	1.55	1.53

Year	Spencer Index	Other Nonmetals: Clay Actual	Clay Relative	Silica Actual	Silica Relative	Talc Actual	Talc Relative	Undistributed Actual	Undistributed Relative
1900-09	36.1								
1910-19	46.3								
1920-29	46.2							$13.97	$30.20
1930-39	27.3	$1.21	$4.43			$7.50	$27.50	11.26	41.20
1940-49	47.5	1.06	2.23	$3.52	$7.40	8.46	17.80	13.82	29.10
1950-59	87.8	1.21	1.38	5.92	6.75	5.77	6.57	20.63	23.50
1960-64	109.0	1.14	1.05	7.41	6.80	5.86	5.38	23.58	21.60

Year	Spencer Index	Fuels: Coal Actual	Coal Relative
1900-09	20.7	$1.98	$9.55
1910-19	29.3	2.58	8.80
1920-29	49.6	3.72	7.50
1930-39	33.1	3.07	9.26
1940-49	66.8	4.77	7.14
1950-59	98.4	7.17	7.30
1960-64	94.0	8.58	9.10

[1] Values for cement are dollars per barrel; other commodity values are dollars per ton.

[2] U.S. Department of Commerce. Raw Materials in the United States Economy: 1900-61. Bureau of Census Working Paper 6, 1964, 139 pp. The decade figure was compiled by aggregating annual data.

MINERALS

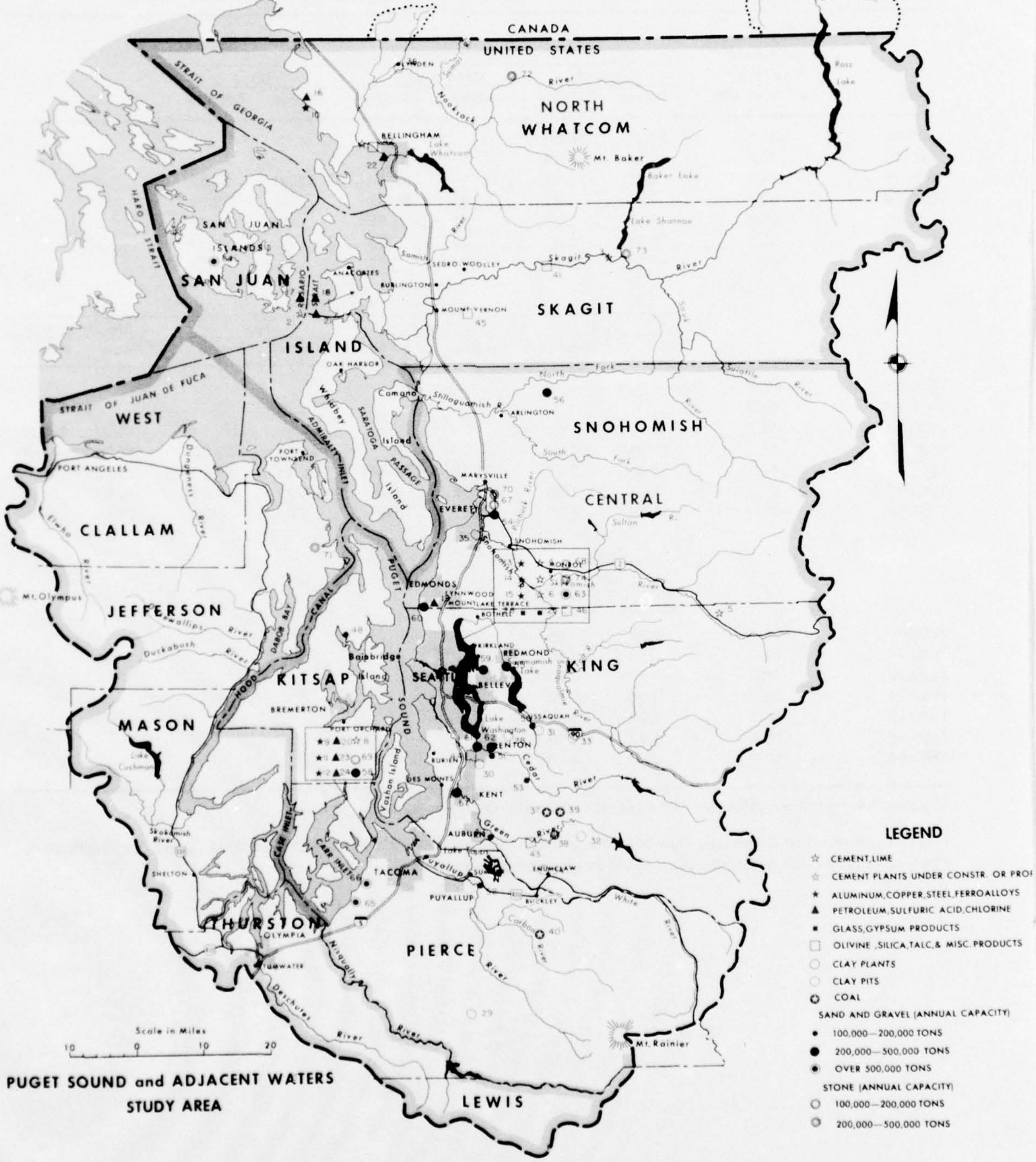


Figure 4-2. Mineral Processing and Related Industrial Operations

Mineral processing and related industrial plants in the Puget Sound Area.

Numbers refer to Figure 4-2.

	Cement
1	Pittsburgh Plate Glass Co.
2	Lone Star Cement Corp.
3	Lone Star Cement Corp.
4	Lone Star Cement Corp.
5	Ideal Cement Co.
6	Kaiser Cement & Gypsum Corp.
	Lime
8	Pacific Lime, Inc.
	Aluminum
9	Kaiser Aluminum & Chem. Corp.
10	Intalco Aluminum Corp.
	Copper (& by-product sulfuric acid)
11	American Smelting & Refining Corp.
	Ferroalloys
12	Ohio Ferroalloys Corp.
	Steel
13	Bethlehem Steel Co., Pac. Coast Div.
14	Northwest Steel Rolling Mills, Inc.
15	Isaacson Iron Works
	Petroleum
16	Mobil Oil Co., Inc.
17	Shell Oil Co.
18	Texaco, Inc.
19	Union Oil Co. of California
20	U.S. Oil and Refining Co.
	Sulfuric acid
21	General Chem. Div., Allied Chem. Corp.
	Chlorine
22	Georgia Pacific Corp.
23	Hooker Chem. Corp.
24	Pennsalt Chemicals Corp.
	Glass
25	Northwestern Glass Co.
	Gypsum
26	Kaiser Cement & Gypsum Corp.
	Clays
28	Builders Brick Co.
29	Builders Brick Co.
30	International Pipe & Ceramics Corp.
31	International Pipe & Ceramics Corp.
32	International Pipe & Ceramics Corp.
33	International Pipe & Ceramics Corp.
34	International Pipe & Ceramics Corp.
35	Lowell Brick & Tile Co.
36	Lynden Clay Products, Inc.
	Coal
37	Coal, Inc.
38	Palmer Coking Coal, Inc.
39	Palmer Coking Coal, Inc.
40	Queen Coal Co.
	Olivine
41	Northwest Olivine Corp.
42	Olivine Corp.
	Silica
43	Smith Bros. Silica Sand, Inc.
44	Cavanaugh Molding Sand Co.
	Talc and miscellaneous
45	Northwest Talc & Magnesium
46	Manufacturers Mineral Co.
	Sand & Gravel, 100,000-200,000 tons
47	Miles Co.
48	North Kitsap Gravel & Asphalt Co.
49	Olympia Oil & Wood Products Co.
50	Reid Sand & Gravel, Inc.
51	Stoneway Sand & Gravel Co.
52	Tim Corliss & Sons
53	Western Sand & Gravel Co.
	200,000-500,000 tons
54	Associated Sand & Gravel Co., Inc.
55	Cadman Gravel Co.
56	Cascade Asphalt Paving Co.
57	Freeway Concrete Supply Co.
58	Holroyd Land Co., Inc.
59	Lakeside Gravel Co.
60	North Star Sand & Gravel Co.
61	Renton Sand & Gravel
62	Renton Sand & Gravel
	Over 500,000 tons
63	Boise Cascade Corp., Klinker Div.
64	Friday Harbor Sand & Gravel Co.
65	Glacier Sand & Gravel Co.
66	Pioneer Sand & Gravel Co.
	Stone, 100,000-200,000 tons
67	Associated Sand & Gravel Co., Inc.
68	Black River Quarry, Inc.
69	Woodworth & Co., Inc.
	200,000-500,000 tons
70	Associated Sand & Gravel Co., Inc.
71	General Construction Co.
72	Kaiser Cement & Gypsum Corp.
73	Lone Star Cement Corp.
74	Puget Sound Bridge & Dry Dock Co.

Water Use by Mineral Industries

The results of a U.S. Bureau of Mines 1962 survey of water requirements for the mineral industry (exclusive of smelters, refineries, and cement plants) of Washington indicated that approximately 9 billion gallons of water were required for mining and processing mineral commodities.

Approximately 82 percent of the total for the State was required in processing sand and gravel; metal mines and mills and nonmetal mines, quarries, and mills each used about 9 percent of the total requirements; processing requirements for coal were less than 1 percent of the total. It is estimated that the fraction of the total water requirement for mineral processing in the Puget Sound Area that is used in sand and gravel processing is considerably greater than the 82 percent for the State as a whole.

In the Puget Sound Study Area recirculating procedures accounted for 427.6 million gallons (8.7 percent) of total water requirements, and new makeup water totaled about 4.5 billion gallons (91.3 percent). Approximately 95 percent (4.2 billion gallons) of the new makeup water was returned to the source; only 227 million gallons (about 5 percent of new makeup water) was consumed in the product or evaporated during processing. Water use in the mineral industry in the Puget Sound Study Area in 1962 is shown in Table 4-5.

For the State as a whole, nonmetal mining and milling operations (excluding sand and gravel operations) utilized extensive water recirculating techniques; approximately 97 percent of the water requirements in nonmetal mining and milling were from recirculated water.

Land Needs for Minerals Development

In the Puget Sound Study Area, as in the United States as a whole, the per-capita growth in demand for mineral resources during the past 50 years has been rapid. This, combined with the

TABLE 4-5. Mineral industry water use, 1962, Puget Sound Area, all commodities[1] (gallons)

Counties	New	Recirculated	Total	Discharged	Consumed	Water Used In Petroleum & Natural Gas
Central						
King	669,200,000	39,700,000	708,900,000	633,320,000	35,880,000	--
Kitsap	43,100,000	3,000,000	46,100,000	41,100,000	2,000,000	--
Pierce	3,448,924,425	20,000,000	3,468,924,425	3,275,490,425	173,434,000	--
Snohomish	121,617,923	347,152,000	468,769,923	115,067,923	6,550,000	--
Total	4,282,842,348	409,852,000	4,692,694,348	4,064,978,348	217,864,000	--
North						
Island	23,760,000	2,340,000	26,100,000	22,570,000	1,190,000	252,000
San Juan	--	--	--	--	--	--
Skagit	40,410,000	9,360,000	49,770,000	38,410,000	2,000,000	--
Whatcom	12,500,000	--	12,500,000	11,900,000	600,000	--
Total	76,670,000	11,700,000	88,370,000	72,880,000	3,790,000	252,000
West						
Clallam	800,000	--	800,000	800,000	--	--
Jefferson	--	--	--	--	--	--
Mason	5,500,000	--	5,500,000	5,250,000	250,000	--
Thurston	101,735,000	6,000,000	107,735,000	96,653,000	5,082,000	--
Total	108,035,000	6,000,000	114,035,000	102,703,000	5,332,000	--
Puget Sound Area Total	4,467,547,348	427,552,000	4,895,099,348	4,240,561,348	226,986,000	252,000

[1] Excludes smelters, refineries, and cement plants.

projected population growth in the Area, emphasizes the need for more minerals.

Although the total amount of land that is presently occupied by mines or will be needed for future minerals industries is extremely small, the need for land for these industries is extremely critical. This critical need for land is the result of two factors: (1) mineral resources themselves are absolutely essential to each and every human activity. Without an adequate supply of minerals at reasonable costs, all activities of all kinds would grind to a halt, not only in the Puget Sound Study Area but in the whole nation; (2) mineral deposits are like "needles in a haystack"—that is, they are very small and very anomalous conditions in the earth. Deposits that are good enough to produce minerals that will meet the strict specifications of the consumers and that are large enough, pure enough, close enough to markets, and that meet all the other requirements so that they can be mined at a profit are very difficult to find.

It has been estimated that in the approximately 115 years since mining first started in the Puget Sound Area, with the opening of a coal mine in the Bellingham area in the 1850's, a total of about 3,070 acres of land has been disturbed by surface mining activities. An additional, but probably smaller, amount of land has been occupied by the surface plants that were built to service the underground mines that have produced in the region in this period of time. Table 4-6 shows a breakdown of the amounts of land disturbed by surface mining by mineral products and by counties. Thus, it is clear that the few thousands of acres of land needed for mineral-resource exploitation is a very small amount as compared with the large amounts needed for intensive use development and the several million acres needed for agriculture, forest products, game management, and recreational uses. However, the mineral-resource need, which is small in terms of acres, is large in terms of dollar value of product, and, as stated previously, the need is critical.

Much of the land that is needed for mineral development is in areas where the land-use competition is keenest. Many metallic ore deposits are found in the high Cascades, where increasing demands are being made for single-use management exclusively for recreation. Unfortunately, the view is widely held that mining developments and recreation must be mutually exclusive. Quite the contrary is actually true. The scars on the landscape that result from mining are very, very small as compared with scars made by other activities which are either no more essential or are much less essential. The access roads necessary for mineral exploration and development are very valuable outdoor recreation assets. Many of the finest scenic areas in the Cascade Mountains are accessible by roads built by mineral explorers and producers.

TABLE 4-6. Land in Puget Sound Area disturbed by surface-mining activities, 1850-1965 (by county)

	Clallam (Acres)	Island (Acres)	Jefferson (Acres)	Kitsap (Acres)	King (Acres)	Mason (Acres)	Pierce (Acres)	San Juan (Acres)	Skagit (Acres)	Snohomish (Acres)	Thurston (Acres)	Whatcom (Acres)	Total (Acres)
Coal (bituminous)					20		10						30
Clays	3			5	90		20		20	20		15	173
Gold (placer)	5				10		10			10		10	45
Manganese	5												5
Peat				30	160	10			10	80	50		340
Olivine									10				10
Sand & gravel	240	25	120	170	375	125	300	20	150	350	150	100	2,125
Stone (limestone)					20			40	20	15		60	155
Stone (other)	10	—	2	20	25	5	10	—	2	10	100	5	189
TOTAL	263	25	122	225	700	140	350	60	212	485	300	190	3,072

Of even more concern is the acceleration of the "urban sprawl" that is rapidly effectively destroying the limited supplies of sand, gravel, and stone in the very areas where they are most needed. When a house, commercial building, or industrial plant is built on land that is underlain by sand and gravel that could have been excavated and sold, these valuable mineral resources are for all practical purposes destroyed. They are removed from possible use—a waste we can ill afford. Land-use planning and zoning laws and regulations that permit this type of waste are obviously inadequate and should be modified.

With respect to land needs for minerals development as related to water management, careful consideration should be given to the locations of mineral deposits that might be flooded by reservoirs behind any proposed dams on the rivers in the Area. Many of the most valuable deposits of sand and gravel in particular are situated in and near the beds of the rivers in the Area.

Because of the high cost of transportation in relation to the total sale price of such mineral products as sand, gravel, and stone, it is important that every effort be made to protect the known sources of these products, especially in reservoir areas and in urban areas where the demands for the products are greatest.

Future Needs for Minerals in the Puget Sound Study Area

Projections—The projections are made on the basis of least squares fits of both linear and logarithmic curves of data. Standard regression techniques are used, and two or more curves are fit to most data. The equations of the curves used are in the form $Y = a + b x$ and $\log Y = a + b x$. The correlation coefficients (r_2) of most fits were computed, and the best fitting curve selected. The accuracy of the projections varies greatly. The expected statistical error of regression techniques is not formally presented, but it is related to the size of the correlation coefficient. The nearer the correlation coefficient approaches 1.00, the better confidence assumed in the projection.

Estimated production of certain minerals in the Puget Sound Area from 1980 to 2020 is shown in Table 4-7. Individual discussions are given for expected requirements of each commodity listed in the Table. A division analysis is given for common construction materials, such as cement, sand and gravel, and stone, since consumption of the materials is dependent to a great extend upon population growth.

TABLE 4-7. Estimated production in Puget Sound Area 1980-2020

	1964	1980	2000	2020
Cement (million barrels)	4.3	5.5	9.0	14.0
Clay (thousand tons)	107	125	150	175
Lime (thousand tons)	47[1]	70	100	175
Peat (thousand tons)	35	50	60	70
Sand & gravel (million tons)	12.4	15	25	35
Stone (million tons)	3.5	5	8	10

[1] Estimated consumption.

Cement—Per-capita consumption of cement in Washington, ranging from a low of 1.01 barrels in 1945 to a high of 2.36 barrels in 1958, has been higher than the United States average throughout the period 1940-60, Figure 4-3. In 1961, the State per-capita usage (1.85 barrels) dropped below the United States average (1.92 barrels) and remained below it through 1964. The reason the State figures have been higher than the national average for many years has been due to large quantities of cement used at dam construction projects in Washington.

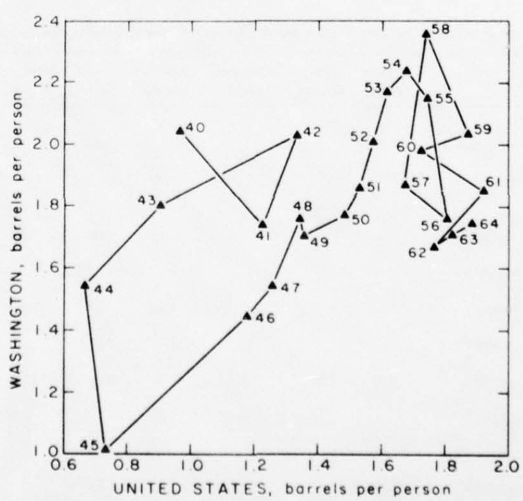


FIGURE 4-3. Washington versus United States per capita cement consumption, 1940-64.

A correlation was prepared comparing Washington cement usage with that of the United States over the period 1950-64, but the test was not significant for prediction purposes. The derived trend line formula (Y = 2.42 - 0.27x) over the period indicates a downward trend in per-capita requirements for Washington compared to the United States total. It is not reasonable to expect the downward trend to continue, but Washington per-capita requirements probably will remain below or equal to the United States figure.

The future estimates of cement production in the Puget Sound Area are based on an average annual increase of 2.5 percent, which is the figure derived for the commercial sand and gravel production trend in the Area appearing later in this report. The average annual production increase of 2.5 percent indicates per-capita consumption requirements of about 2 barrels of cement in the Puget Sound Area throughout the period of this study, or per-capita requirements of 1.96 barrels in 1980, 2.05 barrels in 2000, and 1.97 barrels by 2020.

The trend in the Puget Sound Area is toward reducing labor costs and cement prices by installing larger capacity plants and production machinery combined with centralized controls with electronic or automatic equipment. Firm commitments to install highly efficient cement-producing capacity of 8.5 million barrels annually have been made by companies operating in the Puget Sound Area. This proposed additional capacity will be sufficient to fulfill needs of the Area until 2000 and possibly to 2020, if some existing plants in the Study Area remain in operation. However, as new capacity is completed, some older, obsolescent high-cost production plants will be deactivated or revamped with automated equipment.

Estimated consumption of portland cement by economic division in the Puget Sound Area from 1980 to 2020 is shown in Table 4-8.

TABLE 4-8. Estimated consumption of portland cement by economic division, 1980-2020 (millions of barrels)

Economic Division		1980	2000	2020
I	Central	4.8	7.9	12.4
II	North	0.4	0.6	0.9
III	West	.3	.5	.7
Total Puget Sound Area		5.5	9.0	14.0

Clay—The trend of clay production in the Puget Sound Area for the period 1948-64 (Figure 4-4) is increasing at an average annual rate of 3 percent. However, since 1957, output in the Area has declined sharply because of clay imports from California. Growth estimates based on the regression trend line log Y = 1.9896 + x (.0076) of clay production for the Puget Sound Area, therefore, are unrealistic. Future clay output in the Study Area is predicated upon anticipated brick consumption in the Pacific Northwest, increasing annually at a rate of 0.4 percent to 1985, (24) coupled with expected consumption of clay in manufacturing cement.

Predictions of total clay output in the Area imply an average annual increase of about 1 percent, or 175,000 tons, by 2020.

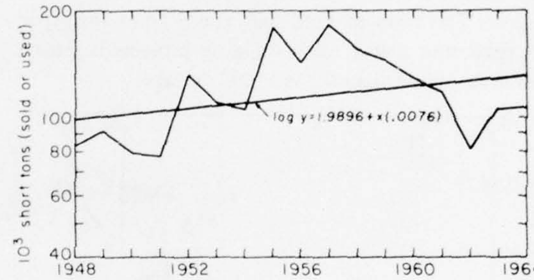


FIGURE 4-4. Clay production in the Puget Sound Area, 1948-64.

Lime—Based on per-capita lime consumption figures for the State of Washington, consumption of primary open-market lime in the Puget Sound Area could more than double over present consumption, or reach 100,000 tons by 2000. Additional lime plant capacity possibly will be installed by that time to fulfill consumption trends. Advantages the Puget Sound Area holds for additional lime-producing facilities are nearness to high-calcium limestone deposits at Texada Island, British Columbia; nearness to major markets in the State, and tidewater location of transportation facilities. Estimates of primary open-market lime consumption in the Puget Sound Area to 2020 are based on per-capita requirements of 0.025 ton.

Peat—The outlook for the peat industry is expected to be one of continued growth. Since 1945, the number of producers in the United States has more than doubled, and domestic output has increased more than fivefold. Consumption in the Puget Sound Area should continue upward, because peat is

in demand by homeowners, landscape gardeners, nurseries, and greenhouses in most parts of the Puget Sound Area, particularly in urban and suburban areas. Future output, expected to reach 50,000 tons by 1980, is projected from past production trends and implies reserve requirements of the magnitude of about 3.5 million tons by 2020.

Sand and Gravel and Stone—Per-capita consumption of aggregates in Washington, ranging from a low of 3.5 tons in 1943 to a high of 13.7 tons in 1964, is compared from 1940 to 1964 with United States figures, which have ranged from a low of 2.6 tons in 1944 to a high of 8.3 tons in 1954 (Figure 4-5). The reason that Washington per capita figures are higher than the national average is that the ratio of sand and gravel from Government-and-contractor operations in Washington is greater than the national figure. The ratio of sand and gravel going into road construction and at dam building projects is greater for Washington than the national average.

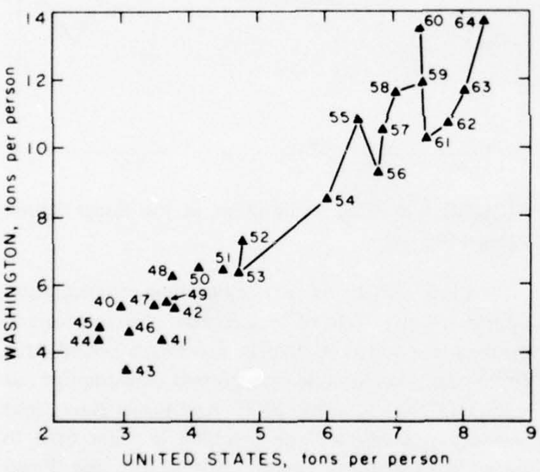


FIGURE 4-5. Washington versus United States per capita sand and gravel and stone production, 1940-64.

For the State, the percentage of sand and gravel from Government-and-contractor operations, ranging from 31 to 54 percent of total output during the period 1950-64, has been much higher than the United States average, Table 4-9. In Washington, the average annual sand and gravel output from Government-and-contractor operations over the 14-year period was 50 percent of total output. The percentage of sand and gravel produced by Government-and-contractor operations in the Puget Sound Area has

TABLE 4-9. Percent of total sand and gravel production from Government-and-contractor operations

Year	Puget Sound	Washington	United States
1950	NA	50	30
1951	36	38	29
1952	31	48	31
1953	26	47	30
1954	27	31	29
1955	28	54	29
1956	33	48	25
1957	46	51	26
1958	35	52	29
1959	32	47	27
1960	22	57	26
1961	32	40	28
1962	34	35	27
1963	24	46	28
1964	20	54	28
Average annual percentage 1950-64	30	50	30

NA Not available.

ranged from 20 to 46 percent of total output, and the 13-year average from 1951-64 is 30 percent of the total. It is expected that this trend will continue in future years, and output by Government-and-contractor operations is estimated to be 30 percent of total output in predicted estimates. The ratio follows the United States trend as the average annual output from 1950-64 from national Government-and-contractor sand and gravel operations, ranging from 26 to 31 percent, was 30 percent of total domestic production. Data are not available for the period 1950-63 at stone operations in the Area, but in 1964, Government-and-contractor operations accounted for 24 percent of total stone output. It is assumed that future production of stone will follow the trend of 30 percent from Government-and-contractor operations.

The projections for aggregates are based on the trend of commercial sand and gravel output in the Puget Sound Area over the period 1951-64 (Figure 4-6). The time series correlation was significant at the 5-percent level of statistical inference, and the trend line $Y = 3 + 0.4x$ implies a 2.5-percent average annual rate of growth for the period of study, or until 2020. Projections for aggregates are made by assuming that this trend accounts for 70 percent of total production or the output from commercial firms. An additional adjustment of 30 percent compensates for production at Government-and-contractor operations.

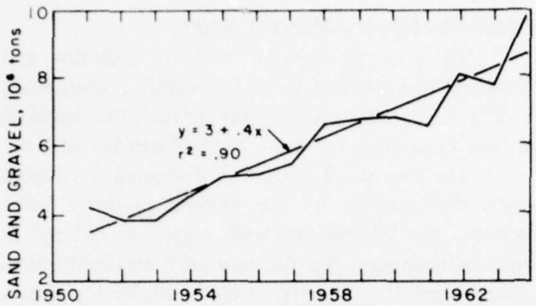


FIGURE 4-6. Sand and gravel produced by commercial firms in the Puget Sound Area, 1951-64.

Estimated per-capita requirements for aggregates in the Puget Sound Area for the projected period of this study are shown in Table 4-10. The per-capita requirements for sand and gravel range from about 5 to 5.75 tons, and per-capita consumption of stone ranges from about 1.5 to 1.75 tons.

The predictions from 1980 to 2020 of sand and gravel production by economic division are shown in Table 4-11. Estimates of stone production from 1980 to 2020 by economic division are shown in Table 4-12. Stone requirements are adjusted upward by 1 million tons in Division II to account for anticipated cement plant requirements for limestone.

Miscellaneous Minerals—Impressive quantities of coal have been produced in the Puget Sound Area in the past, but the high cost of coal production in the Area, coupled with competitive coal sources surrounding the Area and the State, have led to sharp declines in output in recent years. Employment at coal operations in the Area in 1964 was less than 50 men.

Projections have been made for expected future production of coal and employment by the industry in the Pacific Northwest. (24)

The maximum range of the projections is based on a high level of productivity that possibly could not be attained in the steeply pitching coalbeds of the Puget Sound Area. Whereas in 1964, coal output in the Puget Sound Area was about 5.5 tons per employee, the projections imply output of about 30 tons per man by 1985. Minimum growth predicted in the study assumes productivity of about 7 tons per man for all future years; therefore, the minimum predictions for coal output are near current production in the Pacific Northwest. In the absence of dependable information to the contrary, it is assumed

TABLE 4-10. Estimated per-capita requirements for aggregates in the Puget Sound Area, 1980-2020 (tons)

Year	Sand & Gravel	Stone
1980	5.85	1.79
2000	5.69	1.82
2020	4.93	1.41

TABLE 4-11. Estimated production (consumption) of *sand and gravel* by economic subdivision, 1980-2020 (million tons)

Economic Divisions	1980	2000	2020
I	13.0	21.9	30.9
II	1.1	1.8	2.4
III	0.9	1.3	1.7
Total Area	15.0	25.0	35.0

TABLE 4-12. Estimated production (consumption) of stone by economic division, 1980-2020 (million tons)

Economic Divisions	1980	2000	2020
I	3.3	6.0	7.8
II	1.4	1.6	1.7
III	0.3	0.4	0.5
Total Area	5.0	8.0	10.0

that demand for coal and coal output in the Puget Sound Area will remain constant to the year 2020.

Important, but small quantities of olivine, siliceous materials, strontium, and talc are produced annually in the Puget Sound Area. Employment at all mines and plants producing the materials is less than 100 men. Competition makes the future mine production of the materials uncertain.

In the case of olivine, the resource has not been developed to its maximum potential. Many foundry applications for olivine remain to be discovered, and the refractory potential of olivine deserves much more research and development than has been carried out. Olivine from the Twin Sisters area will maintain increased rates of production as the many potential requirements for the mineral are expanded in the future.

One of the few commercial strontium deposits in the United States, and the only one in the

Northwest, is on Fidalgo Island, Skagit County, near LaConner. The deposit contains the two strontium minerals, celestite and strontianite, in approximately equal amounts. In past years, ore was mined intermittently by both underground and open-pit methods, and was processed by the operating company, Manufacturers Minerals Co. The crude material was ground to consumer specifications at the company plant in Seattle and marketed locally as a chemical material.

Copper, lead, zinc, gold, silver, chromite, iron ore, manganese, mercury, and molybdenum have been produced intermittently in small quantities. In 1964, only a small quantity of gold was produced, and employment at all metallic mining operations in the Puget Sound Area during the year was less than 50 men. Curtailment of gold-mining operations during World War II, owing to manpower shortages and the war effort, has hampered development of gold resources. Although the high cost of rehabilitation has prevented many mines from reopening after World War II, a gold subsidy program could possibly result in some mines in the Area reopening for further development.

Government restraint, such as wilderness legislation, could prevent development of these mineral resources in the Puget Sound Area, as the metallic mineral resources have not been delimited sufficiently to ascertain maximum or potential growth.

Means to Satisfy Mineral Needs

There is an obvious need for planning and land-use management so as to provide a continuing supply of the essential mineral commodities required by the expanding economy of the Puget Sound Area.

The very small amount of land needed, coupled with the scarcity of the mineral products being sought, the inflexibility with regard to sources of mineral resources, and the very great flexibility as to sources and large supply of land suitable for almost all other land uses, all point to the need for assigning a high priority to the mineral-resourse use of land.

Mineral resources occur in the Puget Sound Area in sufficient quantities to supply most of the anticipated needs of the Area to the year 2020.

Past experience has shown that, given the opportunity to do so, private industry can supply the mineral needs of the Puget Sound Area.

The key to the means for satisfying the mineral needs of the Puget Sound Area is the word "opportunity". Opportunity in this case will be limited in the largest degree by the wisdom or lack of wisdom exercised in designing and applying the principles of land-use management.

If the local zoning laws and Federal land management laws and regulations are designed and administered so as to encourage rather than prohibit mineral production, a large per cent of the mineral needs of the Area may be supplied from within the Puget Sound Area.

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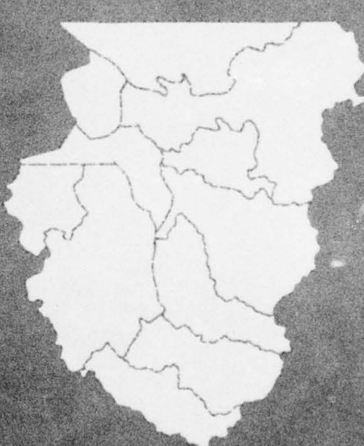
Part Five
Intensive Land Use
Puget Sound Area



PART FIVE—INTENSIVE LAND USE PUGET SOUND AREA

INTRODUCTION

The term "intensive land use" can be characterized for the purposes of this study as those land areas within the Puget Sound Area which are either now, or will be developed for urban-type purposes. The land uses falling within this category include residential, commercial, industrial, streets and highways, and urban-oriented open space. Found within these broad categories of land use are a wide variety of different types of housing: single multi-family, single-lot duplex, high and low rise apartments, new houses, condominiums, etc. Intensive land use is also characterized by differing degrees of development densities—ranging from an extremely high density use of land as found in central city areas to a very low density use of land as found in some outlying suburban and estate areas. While the intensity of land use generally diminishes as distance from the central area increases, there are many exceptions to this general situation—areas of low use intensity near the central area and areas of high use intensity in outlying areas.

To further complicate the matter, it is often difficult to clearly determine whether many land areas are of an intensive or non-intensive character. There are many vacant parcels of land within every urban area ranging from individual lots to large acreages which, for one reason or another, have not yet been developed for urban purposes. However, these vacant lands can generally be included as intensive since they will ultimately be committed to urban use. Areas of permanent open space, park and recreation lands, within urban areas, while having various degrees of use and development are generally considered to be a part of the intensively developed areas. Perhaps the most difficult lands to categorize are those on the fringes of urban areas which are in the process of transition to intensive use. There is often surrounding any urban area a considerable amount of land which has a land use that is in part rural-agricultural-forest and in part urban-oriented in nature. Generally, the line can be drawn where the balance has started to swing to the intensive end of the scale.

The intensive use of land has a significant effect on the water resources of a region. The people occupying these land areas require considerable amounts of pure water for domestic consumption. The industrial complexes located in these areas often require a supply of industrial water for production purposes. There are other less important, but still considerable requirements for water such as recreation, landscape maintenance, fire control and similar items.

The major adverse effect on a region's water quality results from intensive land use areas. Domestic sewage, industrial wastes, solid wastes, storm runoff and similar factors all contribute to create severe water quality problems. The higher the population concentration, the greater the problems become, often requiring tremendous sums of money for corrective purposes.

As land areas are converted to intensive use purposes, the natural drainage system is thrown out of balance. The acres of asphalt and concrete which are laid down upon the earth for parking lots, roads and streets, driveways, playgrounds, etc., severely limit the absorption capabilities of the area, causing drainage and flooding problems. The many buildings themselves have a similar limiting effect on the ability of the remaining open areas to absorb the natural rainfall. Expensive artificial facilities are generally required to prevent water problems in intensive land use areas.

Another major problem is that of flooding. Without proper controls, intensive land uses often locate in flood plain areas, particularly those affected by flooding only infrequently. Furthermore, the development of flood-control devices on some portions of the river system may increase flood possibilities in other portions of the river system. Damages resulting from the encroachment of urban development on flood plains generally result in a call for expensive and previously unnecessary flood control works.

From the preceding discussion, it can be seen that considerations of intensive land uses must play a major role in the planning and management of water resources in the Puget Sound Area. The manner in which urban development occurs will greatly affect the quantity and quality of the region's water resource. Land use planning must be carefully correlated with planning for water resources as the quantities of land required for future urban purposes and its location will be a major factor in determining the quantity and quality of water considered necessary, water sources and distribution systems, flood

control works, waste treatment facilities, flow requirements, and similar factors which are required for the optimum long-range use of the region's water resources.

Urban Land Use

A major segment of the intensive land use reported in this study is that devoted to urban or built-up purposes. The other intensive land use categories are listed as (1) railroads, (2) roadways and, (3) airports. While these latter uses are found in urban areas, a considerable portion of the area occupied by them is located in the non-urban portions of the Puget Sound Area. Since the urban or built-up areas constitute a major use of land, both in terms of area occupied and impact on the total land area, a description of urban land use characteristics and trends is considered desirable as a matter of information.

Categories of Urban Land Use

The following categories are often utilized in recording and analyzing urban land use data:

(1) Residential
(2) Commercial
(3) Industrial
(4) Streets and Highways
(5) Other Public
(6) Vacant

Residential land includes both single-family and various types of multi-family dwellings; industrial includes both heavy and light industry; and commercial areas include wholesaling, retail and service uses. The streets and highways category includes freeways, major and minor arterials and collector streets; while "other public" is composed of a broad range of public and semi-public uses such as schools, parks, public buildings, cemeteries and similar areas. For the purposes of urban-oriented land use analyses, airports and railroads are included with the industrial category, and agricultural land and parking lots are considered as vacant land. Photographs 5-1 through 5-6 show examples of intensive land uses found in the Puget Sound Area.

Urban Land Use Proportions

Each urban area varies somewhat in the composition of its land use proportions. However, sufficient comparability exists nationally between land use arrangements in the various urban areas to allow the development of general urban land use proportions. One example, shown in Table 5-1, has been developed on the basis of data available from a number of major cities.

TABLE 5-1. Mean proportion of urban land uses

Type of Use	Proportion of Total Land	Proportion of Developed Land
Total Developed	.770	1.000
Residential	.296	.390
Industrial	.086	.109
Commercial	.037	.048
Road & Highway	.199	.257
Other Public	.153	.197
Total Undeveloped	.230	
Vacant	.207	
Underwater	.023	

Source: Recent Land Use Trends in 48 Large American Cities, John N. Niedercorn and Edward P.R. Herle, The Rand Corporation, June 1963.

The proportions of urban land use shown above are typical of major cities and are somewhat useful as a general guide. However, it must be remembered that smaller communities, with generally lower densities may vary considerably in their composition. Particularly different are those communities which serve as "bedroom" suburbs for large central cities and often have little or no industrial areas of their own and often limited commercial areas. Other communities may, because of unique circumstances, have a very high proportion of a single use in comparison to other uses such as an industry requiring large land areas, but having a limited employment, requiring only small amounts of residential lands.

Summary of Urban Land Use Characteristics

In a study as broad as the Puget Sound and Adjacent Waters Study, it is most difficult to determine urban land use proportions, and similar factors with any degree of precision. Therefore, the only other alternative is to generalize about the situation. This process is, of course, inherently dangerous for the unwary reader. While generalizations can legitimately be developed expressing proportions of urban land use and density trends, it is most unlikely that many, if any, of the communities in the Puget Sound Area will exactly duplicate the generalized figures.

The urban land use proportion figures reported herein reflect the situation found in major urban centers. Care must be taken in translating these

PHOTO 5-1. The Urban Skyline—Seattle, Washington.

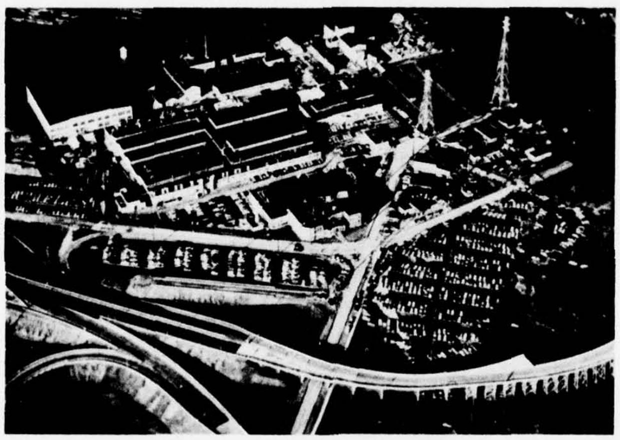


PHOTO 5-2. Industrial and highway uses of land.

PHOTO 5-3. Residential and recreational uses of land.

PHOTO 5-4. Commercial use of land–downtown Olympia.

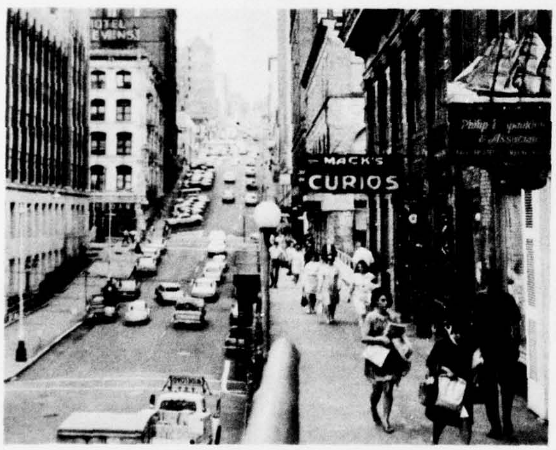


PHOTO 5-5. Commercial development–downtown Seattle.

PHOTO 5-6. Industrial development and Mount Rainier.

figures to a discussion of urbanization on a broad regional basis. For example, the proportionate land use figures reported above generally indicate that 77 percent of urban areas are devoted to some use, while 23 percent is considered vacant. The present study is concerned with a large geographic area containing various types and sizes of urban places. In many of these areas the actual percentage of vacant land will be much higher, particularly in the newly developed or less developed places of smaller size. Conversely, other well developed places in the region may have a much smaller amount of vacant land. Within the boundaries of the city of Seattle, for example, a recent land use inventory indicates a vacant acreage of slightly over 10 percent of the total city area—less than half the average.

Each community, no matter what its size, has certain unique characteristics which set it apart from all others. These characteristics depend on the communities' functions, history, geographic location, employment base, cultural and economic levels and similar factors.

General urban land use proportions are useful as guidelines for a study as broad as the Puget Sound and Adjacent Waters. The detailed planning resulting from this study will require careful consideration of each of the communities involved.

PRESENT STATUS—TRENDS AND POTENTIALS

Intensive Land Uses

Intensive land use has been defined as those land areas which are either now, or will be, developed for urban type purposes. The land uses in this category include residential, commercial, industrial and urban-oriented open space. Specifically, intensive land use has been identified in this study in four major classifications as follows: (1) railroads, (2) roadways, (3) airports and, (4) urban or built-up. The urban or built-up category is the most important with regard to the analysis of intensive land use, plus it is the built-up land use which will have the most significant impact upon the water resources of the area. The discussion in this portion of the report will be concerned primarily with the urban and built-up land uses, and incorporating in less detail, comments on the other intensive land use subgroups. The data presented, with regard to the Study Area, will be reported in general terms because of the magnitude of the materials available, and the large area being examined.

The intensive land use of the Puget Sound Study Area has occurred along the water's edge of the Sound and is concentrated in six major locations, with the largest and most concentrated intensive land use area located in the western portion of the Cedar-Green Basin or the city of Seattle and its surrounding urban environs. The other five primary concentrations of intensive land use are located in and around the cities of Tacoma, Olympia, Bremerton, Everett and Bellingham (Figure 5-1, Land Use Map for Puget Sound Study Area). It is in and around these cities where competition for use of water resources will be the greatest, and where there will be a continual pressure for changes of land use, from less intensive uses to more intensive uses.

The Land Use

The land use of the Puget Sound Study Area, when viewed in its totality, is primarily forest lands which amounts to 84 percent of the total land use of the Area. Considering the range lands and all agriculture lands with the forest lands as non-intensive land uses, 92 percent of the land in the Area is presently being used for non-intensive purposes. The rural non-agriculture land use, (3% of the total) can be defined as an area in transition or an area that does not have a defined prominence in a type of land use. Specifically, intensive land use has been defined as those areas where there are more than three houses to ten acres, commercial areas, industrial areas, cemeteries, railroads and roadways. Thus, by this definition, only 5 percent of the land in the total Study Area is now developed for intensive land use. But it should be remembered that this 5 percent is extremely important when examining its impact upon the water resources of the area. The intensive land use must be viewed as one of the most important inputs of this study. The problems of water resources and intensive land use will increase in the future as population increases and new demands are put on the land.

The Puget Sound Study Area contains 8,404,329 acres of land. This does not include the acreages of inland (fresh and salt water areas) which amount to over 2,708,000 acres within the boundaries of the Area. Land use acreages are reported for the Area in Table 5-2 as follows:

TABLE 5-2. Existing land use by types for the Puget Sound Study Area

Land Uses	Acreages[1]	Percent of Total
Forest	7,039,184[2]	84%
Rangeland	106,448	1%
Cropland	591,513	7%
Rural Non-Agricultural	238,854	3%
Intensive	428,330	5%
Total	8,402,000	100%

1 Unadjusted measurements correct to the nearest thousand.

2 Open lands normally associated with forest areas are included in total forest.

Source: Puget Sound and Adjacent Waters Study, 1966.

Figure 1-2 portrays the existing land use pattern for the Puget Sound Study Area. In viewing this map, it is easy to see that the vast majority of the land is classified as in forest use. It is also easy to see that the intensive land uses occupy only a very small percent (5% of the total acreages in the basin).

The 5 percent of the Study Area that has developed into intensive land uses occupies 428,000 acres of land in the Area. Table 5-3 contains the land use figures for the intensive land use subgroups:

TABLE 5-3. Intensive land use by type for the Puget Sound Study Area (in acres)[1]

Railroads	Roadways	Airports	Urban (Built-up)	Total
12,695	60,964	17,303	337,368	428,330

1 Unadjusted measurements correct to the nearest thousand.

The two subgroups of railroads and roadways contained in Table 5-3 include only those acreages outside of the urban areas. The roadways and railroads contained within the urban areas are included in the built-up or urban subgroup acreages.

Rural Non-Agriculture Land

Much of the land found in this land use group is the forerunner of intensive land uses, thus it is beneficial to include a brief discussion of the rural non-agriculture use of land in this portion of the Appendix. Table 5-4 describes the land use categories of the Rural Non-Agriculture classification.

TABLE 5-4. Rural non-agriculture land use for the Puget Sound Area (in acres)[1]

Rural Non-Farm Residences	River Wash Tidelands	Mines	Farmsteads (Farmyards)	Total
169,949	12,441	17,746	38,718	238,854

1 Unadjusted measurements correct to the nearest thousand.

The rural non-farm subgroup, containing 170,000 acres, and the farmstead subgroup, containing 38,000 acres, both are lands that may be ultimately classified in the intensive land use classification. Mines, while they may or may not have structures associated with their operations, are definitely putting the land upon which the mining operations are taking place to an intensive use. Although the acreage devoted to mining in the Puget Sound Area is small (18,000 acres), these areas are often critical to various intensive land uses, such as suppliers of raw materials to various industries, and for materials to be used in construction of roads, homes, and many other uses.

An Analysis of Intensive Land Use

The urban (built-up) land use can be examined from another point of view than has been previously discussed. John N. Niedercorn and Edward F. R. Herle have developed land use percentages by type for urbanized areas, from a study they performed on 48 large American cities.[1] It is felt that these figures may not be fully applicable when applied to each individual community but should provide a workable basis for analysis of intensive land use types when examining the total built-up area of the Puget Sound. The following categories have been used for examining intensive land use:

> The first land use category is Residential, which includes both single-family and the various types of multiple-family dwellings, and represents the largest land user in the intensive land use areas;
>
> The second category is Industrial, which includes both heavy and light industry. The third category is Commercial, and this includes wholesaling, retail and service uses;

1 Niedercorn, John N., and Edward F. R. Herle, Recent Land Use Trends in 48 Large American Cities, The Rand Corporation, January 1963.

The fourth category of land in the urban areas is Streets and Highways;

The fifth category is Other Public and is composed of a broad range of public and semi-public uses such as schools, parks, public buildings, cemeteries and similar areas;

The sixth category is Vacant, and includes parking lots as well as undeveloped areas.

Also, for the purpose of urban-oriented land use analyses, airports and railroads are included with the industrial categories.

Table 5-5 defines the urban land use breakdown for intensive land uses found in the built-up or urban areas. It provides only an approximation of land acreages for each of the land use classifications found within the built-up sub-group. The approximated land acreages for the Urban Area Land Uses are shown in Table 5-5.

TABLE 5-5. An approximation of urban land uses in acres for the Puget Sound Study Area

Type of Use	Proportion of Total Land*	Approximate No. of Acres
Residential	30%	101,000
Commercial	4%	14,000
Industrial	9%	30,000
Streets and Highways	20%	67,000
Other Public	15%	51,000
Vacant	22%	74,000
Total (Built-up Area)	100%	337,000

*Source: Recent Land Use Trends in 48 Large American Cities, John N. Niedercorn and Edward F. R. Herle, The Rand Corporation, January 1963.

Population Density Patterns

Population densities are an integral input into the analysis of the present status of intensive land use for the Puget Sound Study Area. An examination of the Study Area reveals that there are 4.35 persons per acre on those lands classified as intensive in use. Population densities vary throughout the Study Area, with the areas classified as intensive in the San Juan Basin having just under 1 person per acre, and on those lands classified as intensive in the Cedar-Green Basin, there are just under 6 persons per acre. An examination of a geographical small unit such as the city of Seattle, reveals a population density of over 10 persons per acre. Table 5-6 summarizes the density per acre for those lands classified as intensive in use:

TABLE 5-6. Intensive land use population densities Puget Sound Study Area

Basins	Acreage in Intensive Land Use[1]	Density-Persons Per Acre Intensive Land Use Area
Nooksack	21,000	3.6
Skagit	19,000	2.8
Stillaguamish	7,000	2.4
Snohomish	36,000	4.9
Cedar-Green	167,000	5.85
Puyallup	97,000	3.33
Nisqually-Deschutes	19,000	3.00
West Sound	42,000	2.9
Elwha-Dungeness	6,000	3.3
Whidbey-Camano	11,000	1.8
San Juan	3,000	0.94
Total Puget Sound Area	428,000	4.35

1 Acreages rounded to the nearest thousand.

Economic Activity

An examination of the land use of the Puget Sound Study Area should include a brief review of the economic activities. This examination will provide an insight to the type of land use which has been created. With a physical environment with large acreages in forest lands, it is easy to see why forest products industry (consisting of the lumber, wood, paper and allied products industries) would loom as a major manufacturing industry. However, the largest employment industry is transportation equipment which is made up largely of the vast Boeing complex. The employment in these two major categories far exceeds employment in all other manufacturing industries combined.

Non-manufacturing employment in 1963 accounted for over two-thirds (2/3) of total in the Puget Sound Area, with the largest part of this being found in the categories of trade, services, and government. These groupings of employment tend to be larger in those geographic areas where there is a major concentration of population such as is found in the central portion of the Puget Sound Area.

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TABLE 5-7. Total employment in the Puget Sound Study Area, 1963**

Industry	1963 Employment (in 000's)
*Agriculture, Forest, Fish & Mining	23.7
*Food & Kindred Products	15.9
*Lumber & Wood Products	19.7
*Paper & Allied Products	[illegible].4
*Chemicals	2.3
*Petroleum Refining	1.2
*Stone, Clay & Glass	3.8
*Primary Metals	4.1
Other Non-Durable Manufacturers	15.1
Other Durable Manufacturers	86.2
Transportation, Commerce & Public Utilities	40.2
Wholesale & Retail Trade	140.0
Services	144.0
Construction	41.2
Government	115.8
Total	662.6

*Underlined industries denote large water users.

**Source: Economic Study of Puget Sound and Adjacent Waters, Consulting Services Corporation, Seattle, 1968.

Another important aspect in the examination of the economic activities is that it provides a broad-brush knowledge of the types of industries that exist in the Area, and from this, it can be determined, in general terms, the type of land use needs, plus a knowledge of those industries which are large water users.

Land Ownership

Land ownership can have a definite influence on land use patterns, and as such, has been included in the examination of the intensive land use of the Puget Sound Study Area. As population grows, it will be extremely important to know land ownership to aid in guiding land use patterns in the future, just as it has had an influence on the land use patterns that exist today. Table 5-8 shows the following ownership categories by percent.

Of the total land area in the Puget Sound Area, over 50% is owned by the various governmental units. The Federal government owns 41% of the total land in the Area, with the majority of this amount being in forest lands. The State of Washington owns approximately 9% of the land, and again, a large part of this land is forest land. Lands owned by the local governments largely consist of areas being used for intensive purposes (roads, parks, and other built-up land uses). Special attention should be taken of the large amount of land controlled by the Federal government and private corporations. These large land holders have had an impact on the land use patterns of the past and present, and will have a definite impact upon land use and land use patterns of the future as competition for land use becomes more intense throughout the Area.

TABLE 5-8. Land ownership by percent for the Puget Sound Study Area

Ownership	Percent of Total
Private	29%
Private Corporation	19%
Federal	41%
State	9%
Local Government	2%
Total	100%

Source: Puget Sound and Adjacent Waters Study, 1966.

Urban Land Use Trends

The Puget Sound Area was first settled by persons interested in the potentials offered by lumbering and agricultural pursuits. A number of settlements occurred throughout the area in conjunction with the various lumber mills and in the form of trading communities for the agricultural areas. In the latter portion of the 19th century and the early portion of the 20th century, there were a large number of these small settlements, most of which were occupied by around 100–200 persons. Many of these small communities exist today, although many others are in the category of "ghost towns" at the present time. Of those communities which still exist, their populations have generally either declined in number or have stabilized over the past several decades. Advances in transportation and communication technology have tended to centralize in single locations the services these small scattered communities formerly provided their rural lumbering and agricultural-oriented service areas.

Intensive land use did not become a significant factor in the Puget Sound Area until recent years.

Settlement of the Area began to proceed more rapidly after the turn of the century, with major population increases occurring between 1900 and 1910. Most of this earlier settlement occurred in both the rural areas and within the high density major urban places of the area, requiring small amounts of land for intensive purposes.

Starting just prior to World War II and accelerating in the decade from 1950 to 1960 and from 1960 to the present, significant shifts have occurred in the development pattern of the Puget Sound Area. During this time the rural portions of the area have steadily lost population. Smaller urban communities have generally shown only moderate growth and in a number of cases have experienced declines in population. At the same time, the major urban centers of the Area have grown tremendously. Not only have these urban centers received population from the rural areas and small communities, but they have also received nearly all of the migration to the Puget Sound. For example, the three largest cities in the State: Seattle, Spokane and Tacoma, comprise about 48 percent of the population residing in incorporated places. Cities with populations of 20,000 or more (15 in 1967) include approximately 67 percent of the resident population of incorporated places, while the remaining cities and towns (252 in 1967) have about 33 percent of the incorporated population.

Major urban areas actually include a significant amount of unincorporated territory. These areas are presently accounting for a major amount of the new urban growth and development. This has resulted in the phenomenon of the metropolitan or regional urban complex containing many cities and urbanized but unincorporated territory.

In 1900 there were 264,612 persons, or 51.1 percent of the total populations of the State, residing in incorporated places, compared to 1,931,703 or 60.0 percent in 1967. The addition of some 25 municipalities during the 1950's as well as sizable annexations, did not increase the proportion living in incorporated places. This apparent stabilization is due mainly to the movement of population into unincorporated areas surrounding the larger cities.

As a result of several factors, chief among them advances in transportation and communications technology, the movement to the suburbs has been the major characteristic of urban development since 1945. The personal automobile coupled with the telephone have made it possible for increasing numbers of urban residents to live in widely divergent places according to individual preferences. A widely scattered urban development pattern has resulted from this movement. As a direct result of the urban resident's movement to the suburbs, the amount of land converted to urban uses has increased significantly all over the nation. The Puget Sound Area is no exception to this general situation. Urban land uses once centered in Seattle, Tacoma, Everett, Olympia, Bellingham and other communities have spread significantly into their surrounding unincorporated territory in recent years.

New community incorporations have also occurred in significant numbers around major urban centers. Of the some nineteen (19) incorporated communities surrounding the city of Seattle, nine (9) have been incorporated since 1945 and nearly all have received the bulk of their growth since 1945.

The 1960 United States Census figures for the Puget Sound Area showed that approximately 75 percent of the population in the Puget Sound Area was living in what they defined as urban areas. This figure includes all the incorporated areas, plus the surrounding "built-up" lands. This further exemplifies the urban character of the population in the Puget Sound Study Area.

Intensive Land Use Potentials

The Puget Sound Area has been examined and areas delineated to determine those land areas which would most likely be used for intensive purposes and which are the most likely to actually be converted to urban purpose at various future population levels. This evaluation has resulted in the selection of some 75-80 townships throughout the Area deemed most likely to receive intensive land use development pressures. This amounts to some 1,800,000 acres of land or approximately 20 percent of the total Study Area, based on the examination of present trends projected to the year 2020, plus the suitability and availability of lands in each River Basin to handle the intensive uses.

Obviously, conversion to urban land use of this magnitude would cause a significant decline in other use categories. This could cause a severe impact on the resource balance of the area particularly if conversion were to occur rapidly.

However, conversion to urban land uses will occur over time and this will tend to alleviate many of the adverse impacts. Furthermore, the development pattern will be subject to a certain degree of guidance as various restraints are assumed. In addi-

tion, the full potential intensive land area is likely to be larger than will be needed even under maximum development conditions within the foreseeable future. For example, a future population of 6.8 million would require 50 townships, or over 1,000,000 acres, at a gross density of six (6) persons per acre. Probable higher density figures in some basins coupled with a probable lower projected population figure will result in a lower intensive land requirement during this study time period (the present to 2020). It seems likely that intensive land use demands will be met by the available area for such development for some time to come. If this is the case, a certain portion of the 75-80 townships suitable for urban development will be available for other uses even beyond the 2020 planning target date. Particularly, it will be possible to give significant attention to the physical capabilities of the land within these townships so that only the most suitable acreages will actually be developed for intensive use. It will be possible, then, to reserve substantial acreages for open space and other resource-oriented uses, within the general sphere of influence of future intensive developments.

In the absence of additional specific methods for guiding urban land development, past trends could be expected to continue, and most likely at an accelerated rate. However, as pressures of urban development mount, particularly in the Central Puget Sound Area, some restraints on land development will of necessity come into force. At this point, however, there is every reason to believe that the magnitude of the conversion of land to urban purposes will be one of the most important factors in the development of the Puget Sound Area. Advance planning of a high caliber backed up by implementation must be accomplished in the very near future if the adverse impact of the land use conversion is to be minimized. This is particularly true with certain land uses which require special sites with unique characteristics. These lands must be allocated to those uses which contribute the most to the total environment of the Study Area. A possible example of this type of use could be a deep-water port facility which requires specific land and water requirements. Areas with ample water depth and large backup land acreages are limited in number on the Puget Sound, and an effort must be made in the planning for development in the Study Area to provide for these types of facilities.

The ability of the Puget Sound Study Area to absorb a significant number of new residents will require that proper planning provides a base for wise and efficient use of the Area's major resources of land and water.

A more detailed examination of intensive land use will be done in the section titled "Present Status, Trends and Potentials of the River Basins" (see Part VII).

PRESENT AND FUTURE DEMANDS

Present and future demands for intensive land use have been examined on two levels, the Area-wide level and by each basin. Projected demands for land used for intensive uses were developed from materials presented in the present status section of this chapter, and the population and economic trends as presented in the Economic Appendix. From the combination of these primary sources, plus other selected sources, land use needs for intensive lands have been developed for the Puget Sound Area. The Present and Future Needs section for each of the river basins will follow the River Basin's Present Status section.

The Puget Sound Area—A Basis for Development of Trends

Lands likely to receive pressures to develop to intensive land uses have been projected by the Land Use and Development Technical Committee. This group has projected that there will be over 50 townships that are likely to receive pressures for development to intensive uses by the year 2020. The actual occupancy of lands within the Puget Sound Area will depend upon a number of factors such as actual densities, land use controls, soil conditions and capabilities, the availability of various utilities and facilities, plus a magnitude of private and public investment decisions.

The population projections that have been developed for this study will serve as the primary source for projecting land needs for each of the projection years. The Economic Environment Appendix IV, in addition to providing the population projections, also provides employment figures to 2020. This data provides a framework upon which various types of industrial activities are measured and land needs estimated.

The materials presented in the "Present Status and Trends" section provides a foundation of knowledge of existing intensive land use and immediate land use trends that will give direction to where new facilities are developing.

Land area available for possible expansion to the year 2020 has also been examined in the "Present Status Trends and Potentials" section. This examination revealed a probable maximum of 1,133,000 acres of land needed for intensive land uses by the year 2020. This acreage figure has been determined by using a six persons per acre gross density for a population of 6.8 million by 2020. Probable higher density figures in some of the basins, coupled with a possible lower projected population may result in a lower intensive land use acreage requirement by the end of the study period (2020). Thus, a certain portion of the total acres available for intensive uses may become available for other uses. It should be possible to give significant attention to the physical capabilities of the lands within each basin, and to develop only those lands best suited for intensive land uses. Possibly this will allow for large amounts of land to be left in reserve status, and available for such uses as open space and other resource-oriented uses, within the general sphere of influence of future intensive developments. This approach of providing open space and resource-oriented uses within the areas of intensive land use will assure the people of the Puget Sound Area a continuance or improvement of the living environment they are enjoying at this time in the year 2020.

Population densities and land use configurations should be projected to fit the suitability and capabilities of the lands they are located upon. Special care must be taken to assure that intensive land uses are located on those lands where flooding problems do not exist, where soils are suitable and capable of supporting such uses, plus in those areas where sewer systems are not available, that soils are suitable to handle septic tank systems. Figure 5-1 shows those lands within the Study Area that have flooding and drainage problems. An examination of this map reveals that much of the land within the Study Area has minor to severe restrictions placed upon it for intensive uses, because of these flooding problems.

For projection purposes, the Puget Sound Area has been broken down into three divisions as delineated in Figure 5-2. The divisions are different enough in population characteristics and economic activities that they should be examined individually, and then projections developed for total area, from the divisional picture. A composite of the three subareas has been done to gain the total picture of the Puget Sound Area for each of the plan-projected years.

Table 5-9 shows the population projection for the Puget Sound Area and for the three divisions.

TABLE 5-9. Population Projections PSAW Area 1963-1980—2000-2020

Area	1963	1980	2000	2020
North Division	151,000	185,500	249,900	341,500
Central Division	1,603,000	2,418,900	3,882,100	6,235,500
Vest Division	116,000	122,500	168,500	232,400
Puget Sound Area Total	1,870,000	2,726,900	4,300,500	6,809,400

From Table 5-9, it is easy to see that the greatest population growth will occur in the Central Division for each of the projection periods.

The Central Division will receive an increase of 4.6 million people by the year 2020. This increase will come in increments of 815,000 by 1980; 2,200,000 by 2000; 4,600,000 by the year 2020. It follows that the greatest demands for land conversion to intensive use will occur in the Central Division.

The growth and need for new lands for intensive use will be much less spectacular in both the North and West Divisions, where population is expected to double by the end of the projection period of 2020. Much of this projected growth will be in, and adjacent to, the existing centers of population.

In total, there will be a need for providing land area for 4,939,400 more people by the year 2020 in the Puget Sound Area. Trends indicate that an additional 705,000 acres of land could develop to intensive uses, projected on the basis of an intensive land use density factor of six persons per acre throughout the total Puget Sound Area. This density factor will vary from basin to basin. For the total Study Area, this will provide a low enough density factor to assure that ample lands are available for all the intensive land uses, including the large industrial users, open space recreation uses, and a wide range of residential uses. This relatively low density figure also takes into consideration, where densities per acre are much greater, that there will be ample land for recreation areas and greenbelts, centrally located work areas, and other facilities at close proximity.

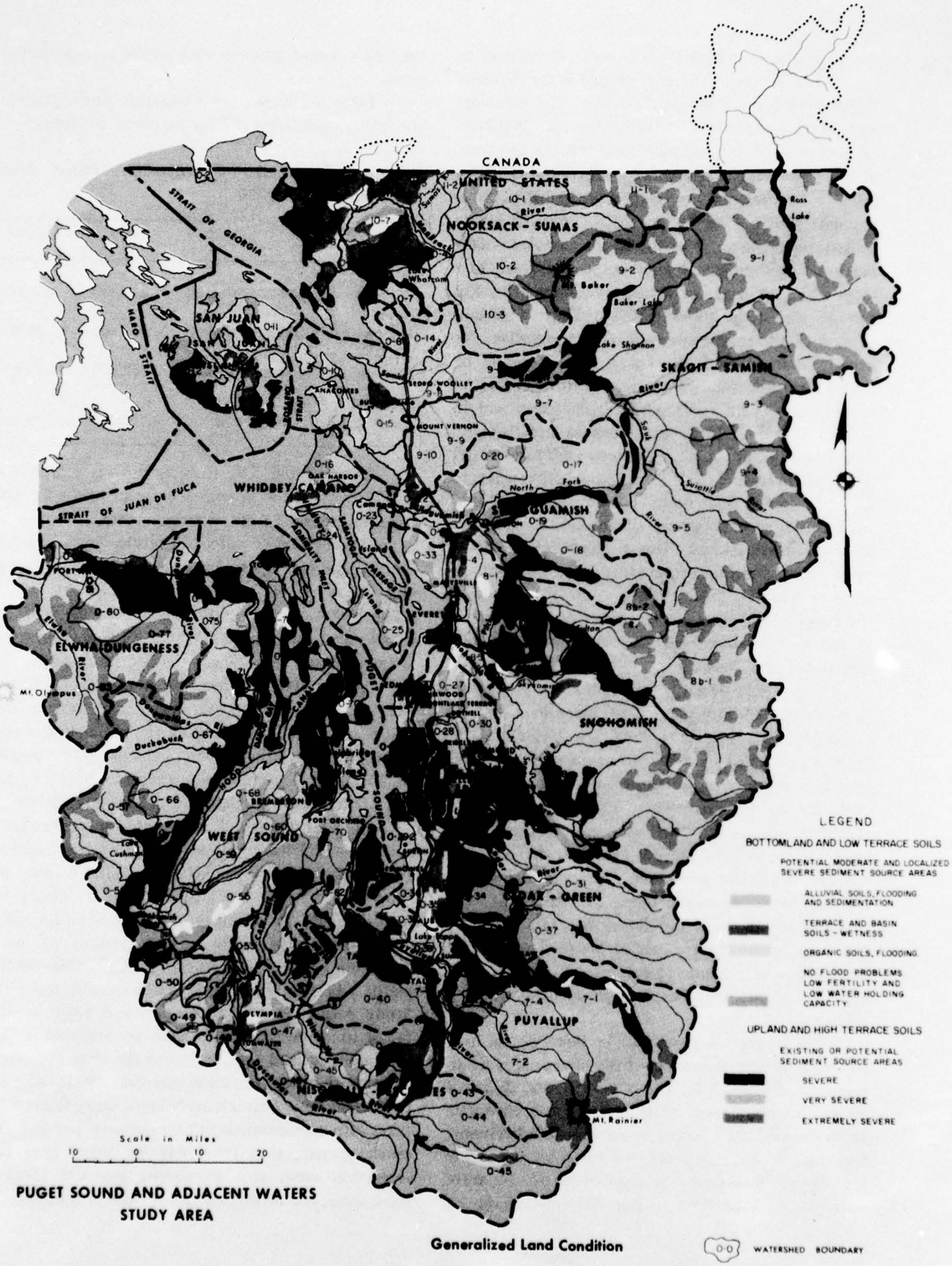

CANADA
UNITED STATES
STRAIT OF GEORGIA
HARO STRAIT
STRAIT OF JUAN DE FUCA
NOOKSACK - SUMAS
SKAGIT - SAMISH
SAN JUAN
WHIDBEY-CAMANO
STILLAGUAMISH
SNOHOMISH
ELWHA-DUNGENESS
WEST SOUND
CEDAR - GREEN
PUYALLUP
NISQUALLY - DESCHUTES
Mt. Baker
Mt. Olympus
Mt. Rainier
OLYMPIA
BREMERTON
MOUNT VERNON
SEDRO WOOLLEY
ANACORTES
OAK HARBOR
PORT ORCHARD
LEGEND
BOTTOMLAND AND LOW TERRACE SOILS
POTENTIAL MODERATE AND LOCALIZED SEVERE SEDIMENT SOURCE AREAS
ALLUVIAL SOILS, FLOODING AND SEDIMENTATION
TERRACE AND BASIN SOILS - WETNESS
ORGANIC SOILS, FLOODING
NO FLOOD PROBLEMS LOW FERTILITY AND LOW WATER HOLDING CAPACITY
UPLAND AND HIGH TERRACE SOILS
EXISTING OR POTENTIAL SEDIMENT SOURCE AREAS
SEVERE
VERY SEVERE
EXTREMELY SEVERE
Scale in Miles
10 0 10 20
PUGET SOUND AND ADJACENT WATERS
STUDY AREA
Generalized Land Condition
0-0 WATERSHED BOUNDARY

FIGURE 5-1

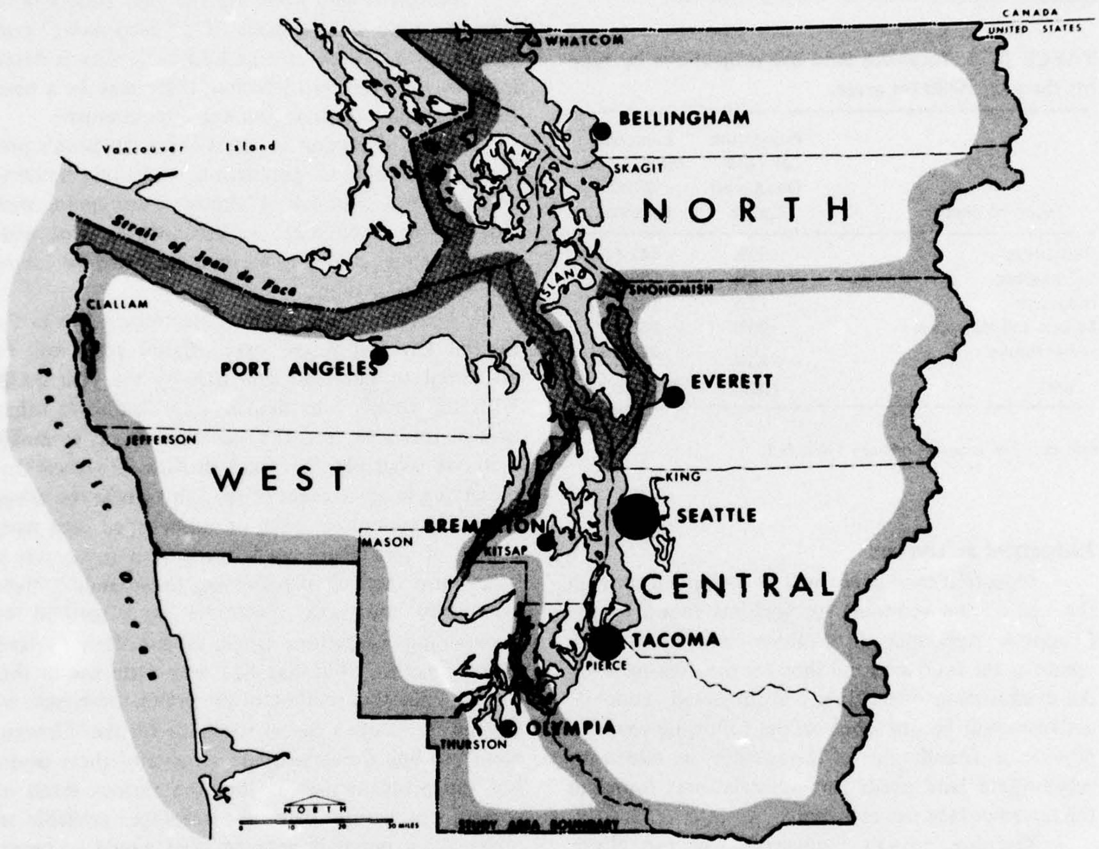


FIGURE 5-2. Economic Divisions of the Puget Sound Area

Table 5-10 shows an approximation of a detailed breakdown of the various types of uses contained within the intensive land use category to the year 2020. It must be stressed that these figures are approximations and should only be used as indicators of land needs to those concerned.

TABLE 5-10. Intensive land use projections by type for the year 2020 (in acres)

Types of Uses	Proportion of Total Developed Lands	Land Use for the Year 2020 (in acres)
Residential	39%	441,000
Commercial	5%	56,000
Industrial	11%	125,000
Streets and Highways	25%	283,000
Other Public	20%	226,000
Total	100%	1,133,000

Source: For proportions see Table 5-1.

Industrial Activities*

Industrial land needs will be examined through the use of the economic projections found in the Economic Appendix. Projections have been developed for the total area and then for the division level. An examination of existing and projected economic activities will be discussed on the following pages to provide a foundation of knowledge in which to substantiate land needs for industrial uses found in the intensive land use category.

The big growth "industries" in the North Division will be aluminum, primary metals, pulp and paper, and government. A large part of this increased government employment will be associated with higher education, or the continual growth of Western Washington College. The projections prepared for this Division will require close scrutiny throughout the period of the plan, as this area may have a much larger growth than has been projected. There are a number of factors that may have a tremendous impact upon future development in this area Some of the factors which may alter the projections are: waterfront resources amenable for developing international and intercoastal trade; near proximity to the fast-growing metropolitan area of Vancouver, British Columbia; and the many amenities that this area has to satisfy a growing tourist market. Thus, from the standpoint of existing projections, close tabs should be kept on this area to assure that the area is growing as projected, and to re-evaluate and up-date projections if the area should "blossom" during the projection period.

Industrial land needs for the year 2020 will be approximately 10,000 acres. If a "deep water" port facility with a large acreage backup facility is developed in the Northern Division, there may be a need to double the industrial land needs requirement.

An examination of the Central Division's projected expansion of population, economic activity, and intensive land use is almost synonymous with that of the total area, as 90% of the area wide activity, (population, economic, etc.) will be taking place in this Division.

Agriculture will have its greatest decline in the Central Division where over 30,000 acres will be converted to intensive land uses by the year 2020. With the tremendous demands for lands for urban uses in this area, and the existence of no workable methods available that will provide a vehicle for preserving large acreages of land in or near the urban areas for agriculture uses or other open area uses, zoning of agriculture lands has proven to be only a short term method of preserving these lands in their agriculture use. Tax incentives as a method of maintaining agriculture lands, is an often "talked about" method, but has had very little use in this country. Another method of preserving these lands in agriculture or open spaces would be for the "Government" to buy the development rights of these lands, but the problem here is that the various levels of government do not have the resources available to undertake a purchase program that would be meaningful. Thus, for projection purposes, and to be realistic, it should be said that much of the agricultural lands that are adjacent to the growing urban areas in the Central Division are now, and will be in the future, converted to urban or intensive land uses.

The big growth "industries", and the term is used loosely, in the Central Division will be transportation equipment, construction, machinery, trade, finance, insurance, real estate and services. Noticeable declines in economic activities will be felt in lumber and wood products, and in agriculture products where the land squeeze will take its toll.

Major growth strength within the West Division will be drawn from the pulp and paper products component of the forest products industry. Growth will demand additional industrial lands. Other growth

factors in the Division will be the new four-year State college which will have a major impact on land use change in the Olympia area. A third area of strength for growth in this Division will be in the tourism, recreation and second-home fields.

The Western Division land use needs could change drastically if a bridge should be placed across the Sound, linking this area with the populous Central Division. The change in land use that would be experienced would be a large increase in land use for housing rather than industry relocating to any degree. Of course, the impact of a bridge will be highly influenced by its location and the amount of tolls that are levied. If, and when, a bridge is constructed across the Sound, the population, and the land use needs, will have to be re-evaluated.

In viewing the total Puget Sound Area to the year 2020, it can be said that industrial growth will have its largest gains from the transportation equipment industry. Other sources of growth will be in the pulp and paper industries and a wide range of manufacturing industries. Lumber and wood industries, along with agriculture-oriented industries, are projected to decline in employment because of resource limitations, increased productivity per person and loss of land to other uses.

Table 5-11 summarizes the employment by industry for the years 1963, 1980, 2000, and 2020. This clearly shows those industries that will have the greatest growth, and it provides an insight into the types of land use needs that will be required to accommodate the new industries over the next 50 years.

The projected intensive land needs expressed in this chapter are "gross" enough to be all inclusive. These projections will provide ample lands for such new uses as nuclear powered electric generating plants, deep-water ports with large acreages of back-up industrial lands, plus other large land users that may exist in the foreseeable future.

Summary of Projections for the Puget Sound Area 1980-2000-2020

Projections to the Year 1980–The highlights of future growth to 1980 are summarized as follows:

(1) Population is projected to increase by approximately 856,000 to 2,700,000 persons in the Puget Sound Area.

TABLE 5-11. Present and projected employment by industry 1963-1980–2020-2020 for the Puget Sound Study Area

Industry	Employment 1963	Employment 1980	Employment 2000	Employment 2020
Agriculture, Forest, Fish & Mining	23,700	18,200	13,500	11,000
Food-Kindred Products	15,900	19,500	22,900	25,600
Lumber-Wood Products[1]	19,700	8,300	2,800	900
		(17,000)	(14,700)	(12,600)
Paper-Allied Products[1]	9,400	14,700	15,900	12,400
		(10,300)	(10,900)	(9,300)
Chemicals	2,300	1,900	1,400	1,000
Petroleum Refining	1,200	1,300	1,400	1,300
Stone, Clay, Glass	3,800	5,000	6,500	8,000
Primary Metals	4,100	7,300	8,700	9,900
Other Non-Durable Manufacturing	15,100	19,700	25,200	30,900
Other Durable Manufacturing	86,000	175,700	380,700	787,400
Transportation, Communications, Public Utilities	40,200	36,200	29,700	23,300
Wholesale, Retail Trade	140,000	202,600	292,300	402,400
Services	144,000	230,100	388,800	627,300
Construction	41,200	54,500	70,500	87,200
Government	115,800	178,100	275,100	405,800
Study Area Total	662,600	973,100	1,535,400	2,434,500

[1] Employment in parentheses represents projections made by the Forest Service, U.S. Dept. of Argriculture, which were available after the completion of the input-output study.

Source: Economic Study of the Puget Sound and Adjacent Waters, Consulting Services Corporation, 1968.

(2) Employment will increase to approximately one million jobs.

(3) Gross Regional Product will double to 11.4 billion in 1963 prices.

(4) Gross Regional Product per person will be up some 34 percent over the 17 year period. This will correspond very closely to the U.S. past history of increases in Gross National Product per person.

(5) In terms of percentages, the North Division is projected to show the largest increase in economic activity with aluminum, petroleum refining and education industries leading the way.

(6) The present economic upsurge in the Central Division will continue with aerospace leading the industrial activity.

(7) The West Division's growth, although slightly less than the Central's rate, draws major strength from the pulp and paper, and food and kindred products industries.

(8) The increased population and economic activity by 1980 will require an additional 142,700 acres of land to be converted from "farming" and forest uses to intensive land uses. This includes land needs for all intensive uses, including industrial, residential, commercial, roads, etc. The largest part of this increase will be located in the Central Division where 815,000 persons of the total 856,000 Puget Sound Area increase will be located. This means that, of the 142,700 acres of additional intensive land use, 135,000 acres will be needed in the Central Division. It is here where the most immediate planning must take place, if we are going to be able to cope with this large increase in intensive land uses, and maintain a high quality living environment. For the Central Division the conversion of lands to intensive uses, and the large influx of people will be magnified for the years beyond 1980, and, if we are unable to cope with the various planning problems that confront us to 1980, there is little hope of maintaining the Puget Sound Area as a "desirable" place to live by the turn of the century.

The pattern of the use of land for future years may very possibly be determined in this period. Great savings to all concerned may be possible in future years in development, construction and even maintenance of our urban areas through the planning that is done in this period. This will require suitable restraints on development in problem or high hazard areas, restraints on scattered development, plus high level and careful detailed planning at the local level.

Projections to the Year 2000—The highlights of growth to the year 2000 are summarized below as follows:

(1) Population is projected to increase to 4,300,500 persons, an increase of 2,430,500 by the year 2000.

(2) Employment in the Puget Sound Area will approach 1,535,000 by the year 2000.

(3) Gross regional or area-wide product will increase five times in 1963 dollars.

(4) The Division growth will continue in a similar pattern to that projected for 1980, with over 90 percent of population and economic activity being concentrated in the Central Division.

(5) This increased population and increased economic activity will require a need for an additional 405,000 acres of land over the 1963 land acreage for intensive land uses. The large growth area will be in the Seattle-Tacoma-Everett metropolitan areas.

Projections to the Year 2020—The highlights of growth of the Puget Sound Area to the year 2020 are summarized below as follows:

(1) Population will pass 6.8 million persons, which will bring about the creation of Pugetopolis.

(2) Gross Regional Product in 1963 dollars is projected to be more than 63 billion dollars.

(3) Employment will approach 2.4 million persons.

(4) Gross regional product per person is anticipated to climb to over the $10,000 mark representing a compounding growth rate of about 2.0 percent per year over the 1963 base.

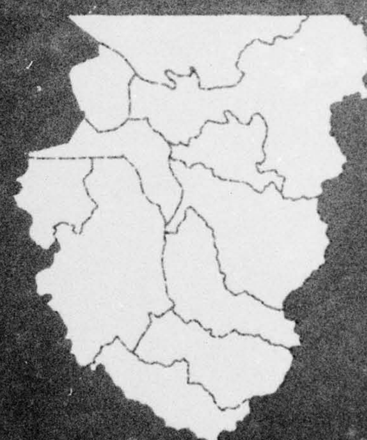
(5) Largest growth is projected for the Central Division where the population will grow to over six million people. The population in both the West and North Divisions will double from the existing 1963 population. Both of these areas may have larger population increases, depending on a number of public and private decisions which would result in greater growth for these areas. An example of such a public decision would be the building of a cross-Sound bridge, connecting the Central Puget Sound Division and the West Division.

(6) By the end of the projected planning period (2020) there will be a need for an additional 600,000 to 700,000 acres of land for intensive use. A breakdown of the intensive land use category would reveal that approximately 40 percent of this land would be utilized for residential development, high-

way and roads would consume another 25 percent, and commercial industrial and public lands would consume the remaining 35 percent. A rough approximation of industrial land use needs for the year 2020, based on 1963 percentage land use figures, shows there will be a need for at least 125,000 acres of land. Care must be taken over the next fifty year to assure proper locations for all land uses within the "Great Scheme" of development. This will be particularly true for industrial lands, as they must be properly located to fulfill their production needs, be properly located to the people who work in the industry, plus they must not distract from our living environment by causing air and water pollution, unsolvable traffic problems, etc., etc.

The projected land use figures contained on the previous pages should be used only as indicators of land needs. As technological advancements change our living patterns, demands for lands will change, and there will be a necessity to re-evaluate the projections contained within this Appendix.

Part Six
Future Land Use
Puget Sound Area



PART SIX—FUTURE LAND USE PUGET SOUND AREA

Future land use for the Puget Sound Study Area has been discussed in detail in the preceding sections of this Appendix. In this section, future land use has been examined within the framework of bringing each of the four major land uses into a common spectrum of analysis and determination of needs from the vast amount of materials gathered in each of the preceding chapters dealing with each of the specific uses. From the analysis and determination of land needs, generalized land use patterns were developed. These are graphically illustrated showing the future land needs for agriculture, forests, minerals and intensive uses for the year 2020.

POTENTIAL LAND USE

Physical Capabilities of Land

Some lands within the Puget Sound Study Area are not suitable for some uses. Land has its special characteristics such as mantle stability, permeability, water-holding capacity, vegetative cover and topography, thus proper considerations must be forthcoming when man attempts to alter the lands. Lands vary widely in their ability to accept development from the natural condition to more intensive use by man. Some areas have the ability, or capability to accept given changes with minimum damage to the stability of the mantle or to the hydrologic cycle. Other areas are critical, and development of these areas may result in widespread damages within and outside the area caused by sediment movement, flooding, and swamping. Each developed area has certain minimum needs for treatment and maintenance in order to allow continued use in the developed situation.

When man develops land for his special purposes he attempts to change the land. His abilities to do this easily are steadily increasing. Earthmoving equipment removes the natural cover and makes limited changes in the topography. Highways and other transportation facilities change the location of major land uses with regard to population centers. Other changes modify the climate to a limited degree by irrigation, or cover the land with pavement and roofs. Good judgement dictates that land be developed carefully from its natural condition so that irreversible changes are not induced in critical areas needlessly, or without full consideration of the consequences. A detailed analysis of the land characteristics can be found in Appendix XIV, "Watershed Management," and in the special exhibit report titled, "Soil Interpretations for Watershed Management and Land Use."

Proper use of the land must be practiced for all the four major land use classifications. Agriculture must practice conservation, with proper cropping of the lands, proper irrigation practices, and the use of those lands which are suited to agriculture pursuits. Forest management must be practiced so as to maintain the forest land at a high level of production, and to assure the maintenance of the watersheds which are located in the forested areas. Proper mining practices must be followed to assure that the land is not permanently scarred, and to assure that the streams and rivers are not polluted by improper mining practices or by the refining process. Misuse of land has been the worst in those areas which are classified as intensive in use and which are located in the suburban areas. Here, precocious development has caused drainage problems, sewerage and pollution problems, an unnecessary reduction of the prime agricultural land, an uncontrolled reduction of the mineral resources, and to a lesser degree, a reduction in the amount of forest lands. Lands which are presently developed for intensive uses represent the greatest challenge for planning for a desirable environment. Through the efforts of an organized planning effort, assurances can be forthcoming that land will not be misused and that development will take place on those lands which are best suited for intensive purposes, and not at the expense of the other land uses.

Suitability of much of the land for a variety of uses, points out the need to plan for the proper use of all lands. There is no great need to displace vast amounts of the fertile river valleys from agriculture uses of the land to intensive land uses, nor is there a need to have a competitive race for the land along the Sound between the industrialist and recreationist as there is ample land for both uses to expand in the future if wise planning takes place at this time.

Spatial Distribution of Land Uses

Land use data has been gathered for each of the following five classifications: croplands, rangeland, forest lands, rural non-agricultural lands and intensive or built-up lands. This data has been examined and refined into four areas of concern for analysis purposes and has been reported in detail in the preceding four chapters on agriculture, forests, minerals, and intensively used land. The rural non-agriculture land use has been examined within the framework of how it affects the agricultural lands, forest lands and intensively used lands. Mining, a sub-category of the rural non-agricultural classification, has been examined in detail (Chapter 4) because of its existing and potential economic impact upon the Study Area. The spatial distribution of present land uses for the Puget Sound Area is shown on Figure 1-2.

The agricultural lands in the Puget Sound Area are found primarily on the flood plains of the rivers that flow into the Puget Sound, and on the low plateaus and bench terrace lands where soils have been of a quality to sustain farming. Much of the agriculture lands are located near existing communities and urban areas, and trends show these lands are receiving continual pressure to convert to intensive uses.

The location of the forest lands can be defined into four major categories with their location being determined by the elevation. Woodland and woodlots are primarily those scattered stands of forests adjacent to the Puget Sound and inland valleys. This is the area that was first logged in early history and is now being put to agricultural, urban and other uses. The principal forests are those areas which extend upwards from the lowlands along the foothills and spur ridges of the Cascade and Olympic Mountains and range in elevation between 500 to 4000 feet. The principal forests contain the bulk of the area's commercial timber land and are the source of 80 percent of the annual harvest. The other two classified forest areas are the upper forest and alpine forest which are found between 3000 and 6000 feet and 6000 feet to the crest of the mountains respectively. The forest lands are of limited value in both of these areas, but are valuable as a recreation resource. Ownership patterns have had a definite influence on forest lands in the past, and will in the future. Large corporate owners, the federal government and, to a lesser degree, the State will provide a large timberland base to assure the area a continuance of large acreages in productive forests.

Mineral resources, while they require a very small amount of land acreage, are important to the economy of the area. The actual significance of the mineral resources in the Puget Sound Area will be influenced primarily by the national policies of prices paid for minerals, and the costs and needs of the minerals. Accessibility to many of these mineral resources will also have a determining factor of whether they will be developed. Mineral reserves such as gravel must be maintained near the urban centers to provide raw materials to the various construction industries.

Intensive land uses are primarily on the lowlands along the Puget Sound, with the major portion being located in the central portion of the Puget Sound Area within the Everett-Seattle-Tacoma urban complex. This trend will continue throughout the planning period with a major portion of the new population settling in the central portion of the Puget Sound Area.

The compatibility of land uses requires good planning. There are ample lands to provide locations for all land uses. Intensive land uses will continue to expand outward from the various urban and community centers infringing on existing agriculture and forest lands. Selective processes for the development of intensive uses must be more critical than they have in the past if urban development is going to be properly located, and not be a detriment of the other major uses. Recreational and industrial uses must be dealt with on an equal basis, especially those that require waterfront locations. A properly conceived plan for the Puget Sound Area will provide ample waterfront lands for both uses, and in many instances, if proper development takes place, industrial and recreational uses can exist side by side.

FUTURE LAND NEEDS

Future land needs have been projected for the major land uses discussed in each of the previous chapters within this Appendix. The Work Groups for each of the chapters have examined the needs for each of the land uses and have projected these land needs through the year 2020.

The agriculture Work Group has defined a need of 525,000 acres of land for cropland purposes by the

year 2020. The 525,000 acres of land are deemed necessary to produce the area's share of foodstuffs that will be needed at this projection period. For this sector to maintain its proportionate share of food and fiber production in 2020, farm production in the Puget Sound Area must be increased as follows: forage and small grain increase 120 percent; field crops increase 264 percent; vegetables increase 255 percent; berries increase 158 percent; nursery products increase 264 percent; and forest products increase 150 percent. To obtain these increases in agricultural production will necessitate installing drainage, irrigation and providing flood protection measures, and by improved technology, crop varieties and other means. This increased agricultural production will have to occur, handicapped with the problem of a reduced land base on which to grow these products.

The Forest Work Group has determined a need of 4,158,400 acres of land to meet forest products needs by the end of the planning period. The acreage requirements have been developed on the basis of conservation measures being practiced, economic processes remaining similar to those used to project needs, technological uses of wood products being similar to those that exist today, and a high level of management being realized. The land base, and existing conditions and trends indicates a yield of about 345 million board feet by 1980, 386 million board feet by 2000, and 408 million board feet by 2020.

No acreage figures have been projected for minerals to the year 2020 because there is a very small need for land acreage for this use, plus the scarcity of minerals and their location dictate where the mining operations will take place. The flexibility as to sources and large supply of land suitable for almost all other land uses, dictates a high priority being placed on the mineral-resource use of land, since it is actually such a small part of the total.

The population will increase to over 6.8 million people by the year 2020, and this will mean a large increase in the land acreages required to meet the needs for intensive land uses in the Puget Sound Area. After an examination of the various land use requirements for each basin, density figures were increased from 6 persons per acre as discussed in the previous chapter to 7 persons per acre (land use pattern A) and 10 persons per acre (land use pattern B). This will result in a need by the year 2020 for 955,100 acres of land for intensive uses under land use pattern A and 653,400 acres of land for intensive use under land use pattern B.

To fulfill the land needs for intensive uses to the year 2020, will require a reduction in the other land uses. To maintain a desirable environment will require that a highly developed planning process be continued in some areas and be forthcoming in others to meet the demands of guiding the development on to those lands which are best suited for intensive uses, and is the least detrimental to the lands presently being put to the other uses. Special efforts must be made to preserve forest land, agriculture land, and provide for open space near the intensive land use areas or urban areas. The projected alternative land use patterns for the Puget Sound Area show the configuation of land uses that may develop by the year 2020. The subsequent paragraphs describe these alternative generalized land use patterns.

PROJECTED ALTERNATIVE LAND USE PATTERNS

Alternative land use patterns have been developed based on two major premises for the Puget Sound Area; the first being the density factor and the second being public investment in a cross-sound bridge and a bridge to Whidbey Island. Alternative land use patterns A and B were developed by using two different densities to determine how this would affect the use of all land in the area by 2020. Alternative land use pattern C is actually alternative land use patterns A and B re-examined in the light of the possibilities of bridges being built across the Sound and between the mainland and Whidbey Island. This would not bring about a larger population in the Puget Sound Area but would cause a reshuffling of the location of the population and consequently the location of intensive land uses. The construction of the bridges will increase intensive land use acreages in the Whidbey-Camano and West Sound Basins, but consequently would result in decreases in intensive land use acreages primarily in the Snohomish, Cedar-Green and Puyallup Basins.

Four alternative land use patterns have been developed in this Appendix to determine what various future public and private influences may have upon the use of the land in the Study Area. Many of the Committees preparing the other Appendices have primarily made their projections of future needs on a basis of present trends extended to the year 2020, or

for the development of a land use pattern similar to alternative land use pattern A, as described in this Appendix.

At the small scale necessary for map inclusion in the text, all four land use patterns appear similar. Therefore, only the maps for land use patterns A and C_2, Figures 6-1 and 6-2 have been included for review in the text.

Alternative Land Use Pattern A

Alternative land use pattern A is a projection of the present pattern of land development, extended to the year 2020. The land use pattern has been developed using a density factor of 7.0 persons per acre as compared to the present which is 4.35 persons per acre.

The rationale behind the density factor used to determine intensive land use needs for a population of 6.8 million persons by 2020 is that the present mode of living will not change greatly through the years, with industrial uses demanding large tracts of land, residential use will continue as a large land user, and there will be a continued demand for a wide variety of urban uses such as parks, schools, etc. It is felt that people will continue to demand single family homes with their large surrounding private yards, thus keeping densities of land development similar to what they are today.

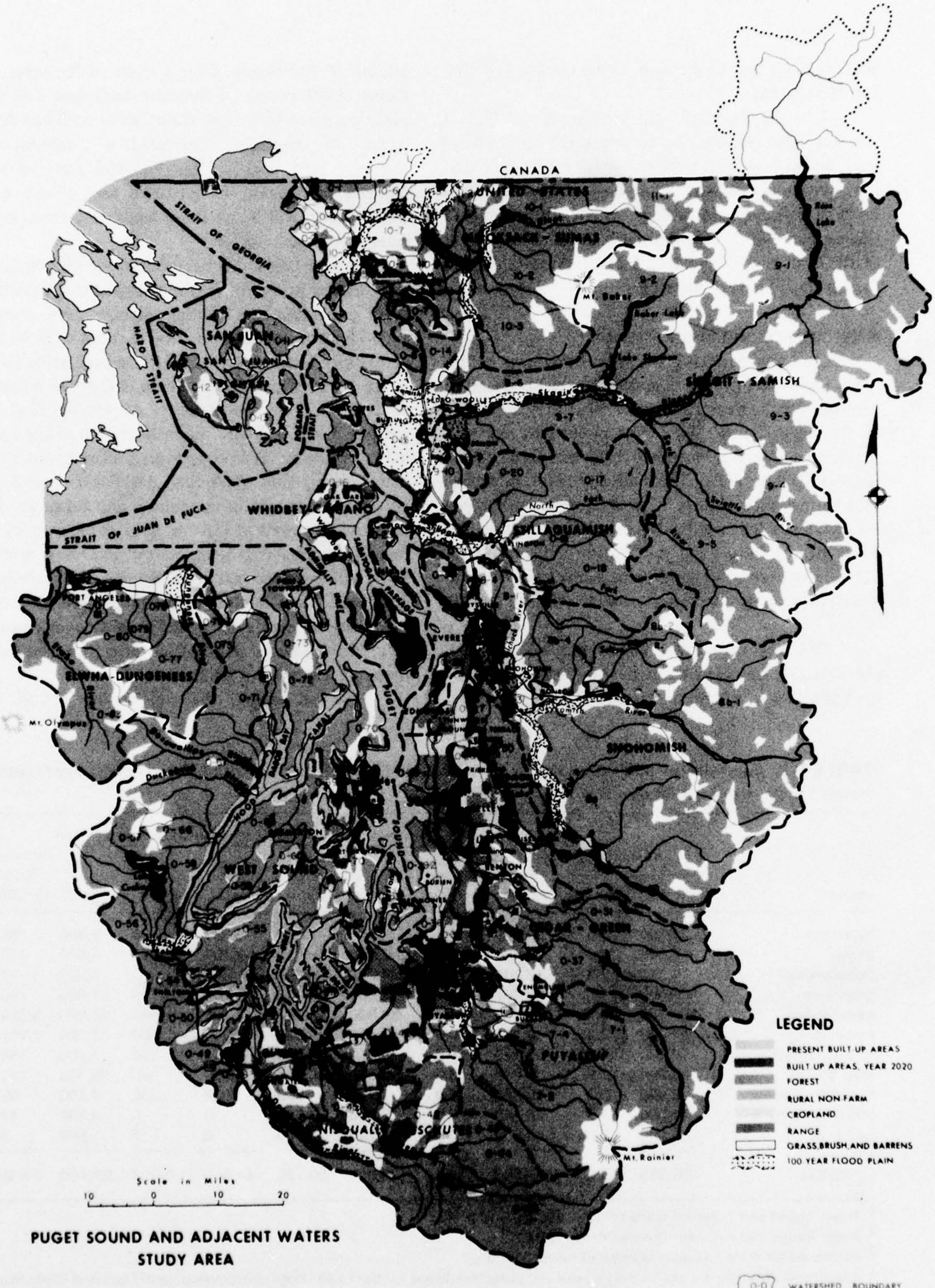
Land use patterns expressed in pattern A will have a significant impact upon the reduction of the agricultural land in the Puget Sound Area. Much of the prime agricultural lands in the Puyallup and Cedar-Green Basins will be consumed by intensive land uses. To a lesser degree, there will also be intensive land use expansion on to the historic flood plains (the agricultural lands) in the Nooksack-Sumas, Skagit-Samish, and Snohomish River Basins. The total reduction of agricultural lands will be 143,000 acres by 2020. A breakdown by basin of those areas where land conversion will take place is shown in Table 6-1. This table shows that a substantial amount of the land conversion taking place in the next fifty years will occur on lands that are presently in the process of change to intensive use, or on those lands now classified as rural non-farm.

Forest lands will be reduced by some 231,000 acres (Table 6-1), a substantial amount, but will have little effect upon the wood products industry as most of the forest lands projected to be developed to intensive uses are found in the small tract ownerships, and are not considered prime forest land. The major portion of the forest industry production in the future will come from those ownerships. The basins which will have the largest acreage reduction in forest

TABLE 6-1. Summary of lands displaced by intensive land use by the year 2020. Puget Sound and Adjacent Waters Study—land use Pattern A

	Present		2020		Acres of Land Displaced by Intensive use by Type					Population
Basins	Acres[2]	Density	Acres[3]	Density[4]	Forest	Rural Non-Farm	Crop land	Range-land	Totals[3]	2020[1] (in 000's)
Nooksack	21,000	3.6	43,300	4.0	14,000	1,000	7,300	0	22,300	168.7
Skagit	19,000	2.8	34,300	3.5	8,000	0	7,000	300	15,300	118.2
Stillaguamish	7,000	2.4	19,000	4.0	8,500	300	3,200	0	12,000	77.8
Snohomish	36,000	4.9	118,000	6.0	22,000	12,000	48,000	0	82,000	780.3
Cedar-Green	167,000	5.85	313,700	12.2	77,000	32,700	36,000	1,000	146,700	3,816.3
Puyallup	97,000	3.33	225,000	5.0	44,000	53,000	27,000	4,000	128,000	1,157.7
Nisqually-Deschutes	19,000	3.0	35,700	4.0	4,000	10,000	1,700	1,000	16,700	146.5
West Sound	42,000	2.9	122,700	3.5	46,100	26,300	6,300	2,000	80,700	432.7
Elwha-Dungeness	6,000	3.3	15,000	3.8	3,000	3,000	2,000	1,000	9,000	56.6
Whidbey-Camano	11,000	1.8	24,800	2.0	4,200	4,200	4,200	1,200	13,800	49.5
San Juan	3,000	0.94	3,600	1.5	200	100	200	100	600	5.1
TOTAL	428,000	4.35	955,100	7.0	231,000	142,600	142,900	10,600	527,100	6,809.4

1 Puget Sound and Adjacent Waters Study, 1968.
2 Puget Sound and Adjacent Waters Study, 1967.
3 Estimated land use acreages rounded to nearest hundred.
4 Population densities for the intensive land use areas developed by the Land Usage & Development Technical Committee, 1967.



PUGET SOUND AND ADJACENT WATERS STUDY AREA

FIGURE 6-1

Generalized Land Use
Alternative A—2020

lands will be the Snohomish, Cedar-Green, Puyallup and West Sound.

The disadvantage of pattern A is that it requires large acreages to be converted to intensive uses, which results in large reduction in all other land uses. With a low density of population, land costs will be large per acre, and this cost will be a direct cost to the people, both through higher cost for development of the land, and for the need for high taxes to be paid for the higher cost of services.

Alternative Land Use Pattern B

Land use pattern B has been developed within the framework of more than doubling the population densities by the year 2020, over what they are today in the Puget Sound Area. The philosophy for new development in this proposed land use pattern is to promote greater use of lands already in intensive use, plus an increased density of development and people on new lands that will be developed for intensive use. This higher density of population will result in 300,000 less acres of land being converted to intensive uses than required in alternative land use pattern A.

This land use pattern has been developed with the objective being to guide new intensive land uses to those lands where trends show development is evident in the future. Over a third of the projected future development of intensive land uses will take place on those lands now classified as rural non-farm, which are generally considered a forerunner of intensive land uses. Of the 225,400 acres of land deemed to develop to intensive uses (Table 6-2), 80,700 acres will be on those lands now classified as rural non-farm.

Forest lands will be reduced by 98,000 acres. This will be primarily on the marginal forest lands or small tracts near the existing urban centers. Agricultural lands or croplands will be reduced only 44,600 acres, with a large portion of the change being found in the Cedar-Green Basins where changes to intensive land use will be the greatest. Alternative land use pattern B will promote the maintenance of the forest and agricultural lands at acreages similar to those that exist today, thus providing the Puget Sound the ability to maintain its agriculture and forest productions at the levels at least as great as exist today. In fact, it is probable that agriculture and forest production will increase per acre as new technology is developed, new lands are put under irrigation, and other advancements are made, thus allowing this area to produce a larger share of its agriculture and forest needs on less acres of land.

Another benefit that will accrue through the

TABLE 6-2, Summary of lands displaced by intensive land use by the year 2020. Puget Sound and Adjacent Waters Study—Land use Pattern B

	Present		2020		Acres of Land Displaced by Intensive use by Type					
Basins	Acres[2]	Density	Acres[3]	Density[4]	Forest	Rural Non-Farm	Crop land	Pasture	Totals[3]	Population 2020[1] (in 000's)
Nooksack	21,000	3.6	29,800	5.5	4,900	600	4,300	0	9,800	168.7
Skagit	19,000	2.8	23,600	5.0	1,500	300	2,700	100	4,600	118.2
Stillaguamish	7,000	2.4	12,700	6.0	4,000	600	800	300	5,700	77.8
Snohomish	36,000	4.9	87,000	8.0	22,900	19,000	9,100	0	51,000	780.3
Cedar-Green	167,000	5.85	232,100	16.5	30,800	14,300	19,400	500	65,000	3,816.3
Puyallup	97,000	3.33	144,200	8.0	20,500	22,000	4,200	500	47,200	1,157.7
Nisqually-Deschutes	19,000	3.0	23,500	6.0	1,300	2,700	300	200	4,500	146.5
West Sound	42,000	2.90	71,000	6.0	6,800	19,200	2,900	200	29,100	432.7
Elwha-Dungeness	6,000	3.3	10,800	6.0	2,700	900	900	300	4,800	56.6
Whidbey-Camano	11,000	1.8	14,100	3.5	2,500	600	0	0	3,100	49.5
San Juan	3,000	0.94	3,600	2.0	100	500	0	0	600	5.1
TOTAL	428,000	4.35	652,400	10.4	98,000	80,700	44,600	2,100	225,400	6,809.4

1 Puget Sound and Adjacent Waters Study, 1968.
2 Puget Sound and Adjacent Waters Study, 1967.
3 Estimated land use acreages rounded to nearest hundred.
4 Population densities for the intensive land use areas developed by the Land Usage and Development Technical Committee, 1967.

development of the land use patterns expressed in alternative land use pattern B is a saving in dollars to both the private and public sectors of the economy, through the reduction of installations of utilities such as water, sewer, power and a savings on other public services.

The question that must be raised at this point is whether it will be feasible to deviate from the present trends, increase densities, and only develop 225,400 additional acres of land to intensive uses. To gain a program that would promote higher population densities and consequently high land use densities, will require decisions by the various levels of government that would promote higher densities of development of land, plus an acceptance by the private sector, and a realization of the savings that would be made by lower development costs, etc.

Alternative Land Use Patterns C_1 and C_2

Alternative land use patterns C_1 and C_2 are an adaptation of the land use patterns A and B with the advent of a cross-sound bridge and a bridge between the mainland and the southern part of Whidbey Island. These two major public improvements will have a tremendous impact upon the land use patterns of Whidbey Island, West Sound Basin and on the central portion of the Puget Sound Area in general.

Using the population densities similar to those used in alternative land use pattern A (C_1) by the year 2020, there would be an additional 64,000 acres of land developed for intensive uses on Whidbey Island, compared to 14,000 additional without the bridge. Using the population densities expressed in alternative land use pattern B (C_2), there would be over 32,000 additional acres of intensive land uses compared to 3,000 without the construction of the bridge. Tables 6-3 and 6-4 show a breakdown of each of the basins, and how they will be affected by the development of intensive uses under these two land use patterns.

In the West Sound Basins a bridge connecting the mainland to the Peninsula via Vashon Island would create a need for an additional 138,000 acres to be developed for intensive uses at densities expressed in alternative land use pattern A (C_1). C_2 would result in an additional 58,000 acres needed for intensive uses by the year 2020. Tables 6-3 and 6-4 show a breakdown of how each land use in each basin will be affected by the development of intensive uses under these two land use patterns.

Land Needs for the Year 2020

In each of the prerevious chapters dealing with a major land use, the examination and analysis has developed a *minimum acreage figure needed to satisfy* land requirements for a population of 6.8 million by the year 2020.

The Agriculture Work Group has defined a need of 525,000 acres of land to satisfy cropland requirements by the end of the planning period. Presently, there are 592,000 acres of land being put to agricultural cropland uses. Thus, a reduction of over 70,000 acres of cropland by the year 2020 would result in the Puget Sound Area's inability to produce its share (percentage of total needs) of agricultural products. From this standpoint, only the land use patterns expressed in B and C_2 will provide ample lands to satisfy agriculture's production requirements.

The Forest Work Group has defined land needs for the year 2020 at 4,153,400 acres to satisfy forest product requirements. Present acreages in forest land are about seven million acres. Even with the vast amount of forest lands that will be taken for other uses such as roads, power rights-of-way, parks, etc., plus the large acreages for intensive uses, all alternative land use patterns would still provide ample lands to satisfy forest needs. Yet, it is important that proper conservation be practiced so as to assure future generations a continuing supply of forest products.

Since the land needs for minerals are extremely small, all alternative land use patterns would meet the land requirements for the minerals. The key to the means for satisfying the mineral needs of the Puget Sound Area is to maintain the "opportunity" to mine these resources. Opportunity will be limited in the largest degree by the wisdom, or lack of wisdom, exercised in designing and applying the principles of land-use management. If the local zoning laws, State and Federal land management laws and regulations are designed and administered so as to encourage rather than prohibit mineral production, a large percent of the mineral needs of the area may be supplied from within the Puget Sound Area.

Intensive land uses presently occupy 428,000 acres of land in the Puget Sound Area. The four alternative land use patterns projected to the year 2020 show there will be a need for an additional 225,000 to 589,000 acres for intensive uses depending on what density the population settles on the land. Judging from the land needs projected for all

PUGET SOUND AND ADJACENT WATERS STUDY AREA

Generalized Land Use
Alternative C2 —2020

FIGURE 6-2

TABLE 6-3. Summary of the lands displaced by intensive land use by the year 2020. Puget Sound and Adjacent Waters Study—Land use Pattern C_1

	Present		2020		Acres of Land Displaced by Intensive use by Type					
Basins	Acres[3]	Density	Acres[4]	Density[5]	Forest	Rural Non-Farm	Crop land	Range-land	Totals[4]	Population 2020[1] (in 000's)
Nooksack	21,000	3.6	42,300	4.0	14,000	1,000	6,300	0	21,300	168.7
Skagit	19,000	2.8	34,300	3.5	8,000	0	7,000	300	15,300	118.2
Stillaguamish	7,000	2.4	19,000	4.1	8,500	300	3,200	0	12,000	77.8
Snohomish	36,000	4.9	114,000	6.7	21,000	12,000	45,000	0	78,000	761.4[2]
Cedar-Green	167,000	5.85	295,700	12.2	68,000	31,700	28,000	1,000	128,700	3,619.9[2]
Puyallup	97,000	3.33	201,000	5.8	41,000	40,000	20,000	3,000	104,000	1,107.5[2]
Nisqually-Deschutes	19,000	3.0	35,700	4.1	4,000	10,000	1,700	1,000	16,700	146.5
West Sound	42,000	2.90	180,000	3.5	84,800	35,000	16,000	3,000	138,800	632.7[2]
Elwha-Dungeness	6,000	3.3	15,000	3.8	3,000	3,000	2,000	1,000	9,000	56.6
Whidbey-Camano	11,000	1.8	75,000	1.5	41,000	11,000	10,800	1,200	64,000	115.0[2]
San Juan	3,000	0.94	3,600	1.4	200	100	200	100	600	5.1
TOTAL	428,000	4.35	1,016,400	6.7	293,500	144,100	140,200	10,600	588,400	6,809.4

1 Puget Sound and Adjacent Waters Study, 1968.
2 Population projections adjusted to meet a population shift with the advent of bridges being constructed between the mainland and the peninsula, and between Whidbey Island and the mainland.
3 Puget Sound and Adjacent Waters Study, 1967.
4 Estimates rounded to the nearest hundred.
5 Population densities for the intensive land use areas developed by the Land Usage and Development Technical Committee, 1967.

TABLE 6-4. Summary of the lands displaced by intensive land use by the year 2020. Puget Sound and Adjacent Waters Study—Land use Pattern C_2

	Present		2020		Acres of Land Displaced by Intensive use by Type					
Basins	Acres[3]	Density	Acres[4]	Density[5]	Forest	Rural Non-Farm	Crop land	Rangeland	Totals	Population 2020[1] (in 000's)
Nooksack	20,900	3.6	29,800	5.7	5,000	600	3,300	0	8,900	168.7
Skagit	18,800	2.8	23,600	5.0	1,600	300	2,800	100	4,600	118.2
Stillaguamish	6,700	2.4	12,700	6.1	4,200	600	900	300	6,000	77.8
Snohomish	36,300	4.9	84,000	9.1	20,800	18,900	8,000	0	47,700	761.4[2]
Cedar-Green	166,400	5.85	222,900	16.2	25,300	13,100	17,600	500	56,500	3,619.9[2]
Puyallup	97,400	3.33	138,200	8.0	17,300	19,800	3,200	500	40,800	1,107.5[2]
Nisqually-Deschutes	19,900	3.0	23,500	6.2	1,000	2,200	200	200	3,600	146.5
West Sound	42,200	2.90	100,300	6.3	25,900	27,900	4,000	300	58,100	632.7[2]
Elwha-Dungeness	5,900	3.3	10,800	5.2	2,800	900	900	300	4,900	56.6
Whidbey-Camano	11,000	1.8	43,000	2.7	20,000	9,500	2,000	500	32,000	115.0[2]
San Juan	2,800	0.94	3,600	1.4	100	700	0	0	800	5.1
TOTAL	428,300	4.35	692,400	9.9	124,000	94,500	42,900	2,700	264,100	6,809.4

1 Puget Sound and Adjacent Waters Study, 1968
2 Population projections adjusted to meet a population shift with the advent of bridges being constructed between the mainland and the peninsula, and between Whidbey Island and the mainland.
3 Puget Sound and Adjacent Waters Study, 1967.
4 Estimates rounded to the nearest hundred.
5 Population densities for the intensive land use areas developed by the Land Usage and Development Technical Committee, 1967.

the land uses, only alternative land use patterns B and C_2 will satisfy the land needs for all uses to the year 2020. These two land use patterns will provide ample lands for agricultural and forestry pursuits so that they will be able to maintain their relative importance to the total economy of the area by the end of the planning period. The projected higher population densities of the two land use patterns would result in lower costs for the development of land to intensive uses, which then would result in a direct savings to the people of the Study Area, or would provide the possibilities of additional monies being available to be spent on the improvement of man's total living environment.

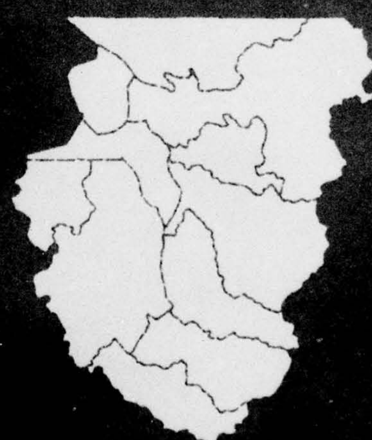
Because of the above stated reasons, and other related statements within this Appendix, the Land Usage and Development Technical Committee recommends that the population growth, and consequently the locations of intensive land uses, follow a pattern similar to those expressed in alternative land use patterns B or C_2. More specifically, assuming that the bridges will be built after 1980 across the Sound from the mainland to the Peninsula via Vashon Island, and from the mainland to Whidby Island, the Land Usage and Development Technical Committee recommends that Land Use Pattern C_2 be followed. Figure 6-2, a map of land use C_2, graphically expresses the suggested development pattern for the year 2020.

If a land use pattern similar to B or C_2 is to develop by the year 2020, there will be a need for stronger land use controls, a need for a more sophisticated level of planning at all levels of government, plus greater support to local planning from the State and Federal governments in the form of technical and financial assistance. Only through the development and use of stronger land use controls, a continual desire by the people of the Puget Sound Area for a balanced living environment, and wise decision-making on the part of government and private enterprise can the Puget Sound Area maintain its desirability as a higher quality living environment.

THE NEED FOR A CONTINUING STUDY

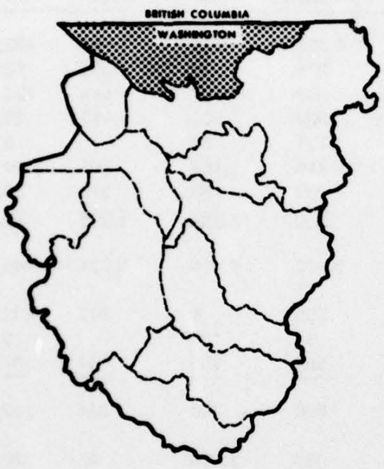
This Appendix, along with the other fourteen Appendices, plus the Summary Report, contains a wealth of information. But to fully benefit from the material gathered, there is a need to keep it current. This can only be accomplished by making the Puget Sound and Adjacent Waters Study an on-going operation, so that all materials that have been gathered are available and updated to meet the needs of water and related land resources for the Puget Sound Area. With the rapid changes in technology, and the changing needs that will be forthcoming in the future, it is necessary to continually re-evaluate the findings and recommendations found in this Appendix and the other parts of the Puget Sound and Adjacent Waters Study.

Part Seven
Water Related Land Resources in the Basins



PART SEVEN—WATER-RELATED LAND RESOURCES IN THE BASINS

NOOKSACK-SUMAS BASINS



The Nooksack-Sumas Basins are located in the north sector of the Puget Sound Area immediately adjacent to the Canadian Border. The Area includes portions of Skagit and Whatcom Counties and contains a hydrologic area of some 804,000 acres. As well as the Nooksack and Sumas drainages, the area includes a portion of the Chilliwack River drainage and several small drainages that flow directly into Puget Sound. The principal drainage in the area is that of the Nooksack River.

Population

The population of the basins in 1967 was 77,300 persons. This population is primarily located in the western third of the basins. Projections show that the population will grow to 91,600 by 1980, 123,500 by 2000 and 168,700 persons by the year 2020. This growth will take place adjacent to the existing areas of development in the western portions of the basins.

Land Use

The primary land use in the Nooksack-Sumas Basins is forest and associated lands with over 75% of the total basin being put to this use. The other two major uses, croplands and urban or intensive land uses occupy 17 percent. and 3 percent of the land respectively and are primarily within the basins. Table7-1 shows the tabulation of present land use within the basins. Figure 7-1, the generalized land use map of the Nooksack-Sumas Basins, portrays the land areas occupied by each of the major uses.

TABLE 7-1. Land use in Nooksack-Sumas Basins (acres)[1]

Map No.	Watershed	Crop-land	Range-land	Total Forest[2]	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
10-1	N. Fork Nooksack R.	2,278	579	176,174	1,352	594	1,264	182,241
10-2	M. Fork Nooksack R.	202	92	62,291	225	35	356	63,201
10-3	S. Fork Nooksack R.	4,185	1,109	115,478	999	407	985	123,163
10-4	M. Tribs. Nooksack R.	7,754	322	14,250	936	469	1,417	25,148
10-5	Anderson Creek	2,241	317	6,024	121	86	--	8,789
10-6	Bertrand-Fishtrap Crs.	18,501	309	3,237	716	1,151	265	24,179
10-7	Wiser Lake–Ten-mile A.	27,265	1,402	8,061	797	780	310	38,615
10-8	L. Tribs. Nooksack R.	14,511	387	3,269	826	842	1,024	20,859
	Total Nooksack	76,937	4,517	388,784	5,972	4,364	5,621	486,195
11-1	Upper South Tribs.	125	--	108,837	265	4	247	109,478
11-2	Saar Creek	3,512	109	5,769	91	129	--	9,610
11-3	Sumas River	18,287	923	12,650	564	655	137	33,216
	Total Fraser-Sumas	21,924	1,032	127,256	920	788	384	152,304
0-1	Dakota Creek	8,270	847	9,706	483	1,008	52	20,366
0-2	Coastal Creeks	4,363	768	7,681	1,705	2,185	3	16,705
0-3	Terrell Creek	5,581	620	2,773	241	288	438	9,941
0-4	California Creek	8,384	771	4,118	392	527	69	14,261
0-5	Silver Creek	5,704	419	3,479	662	602	139	11,005
0-6	Squalicum Creek	4,504	1,315	7,575	779	3,063	48	17,284
0-7	Lake Whatcom	650	565	30,317	673	4,630	5,198	42,033
0-8	Chuckanut Mountain	366	183	18,217	266	3,320	177	22,529
0-9	Lummi Island	809	563	9,675	576	121	--	11,744
	Total Pacific Drainages	38,631	6,051	93,541	5,777	15,744	6,124	165,868
	Nooksack-Sumas Basins	137,492	11,600	609,581	12,669	20,896	12,129	804,367

1 Unadjusted measurements, 1966, for Puget Sound Area Study.

2 Figures include non-forested lands commonly associated with forest areas.

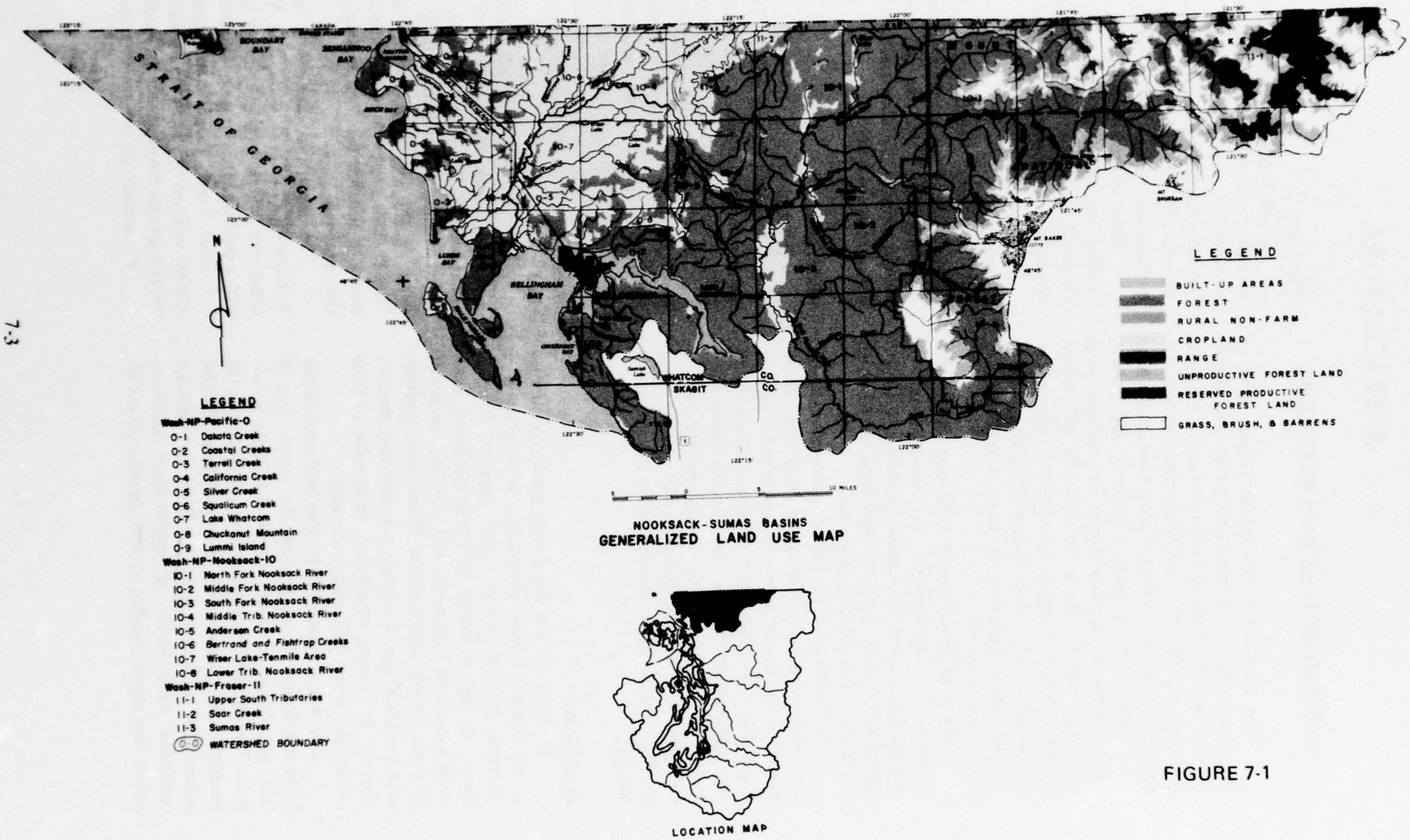

STRAIT OF GEORGIA
BOUNDARY BAY
SEMIAHMOO BAY
BIRCH BAY
LUMMI BAY
BELLINGHAM BAY
CHUCKANUT BAY
WHATCOM CO.
SKAGIT CO.
MT BAKER
MT SHUKSAN
LEGEND
BUILT-UP AREAS
FOREST
RURAL NON-FARM
CROPLAND
RANGE
UNPRODUCTIVE FOREST LAND
RESERVED PRODUCTIVE FOREST LAND
GRASS, BRUSH, & BARRENS
LEGEND
Wash-NP-Pacific-0
0-1 Dakota Creek
0-2 Coastal Creeks
0-3 Terrell Creek
0-4 California Creek
0-5 Silver Creek
0-6 Squalicum Creek
0-7 Lake Whatcom
0-8 Chuckanut Mountain
0-9 Lummi Island
Wash-NP-Nooksack-10
10-1 North Fork Nooksack River
10-2 Middle Fork Nooksack River
10-3 South Fork Nooksack River
10-4 Middle Trib. Nooksack River
10-5 Andersen Creek
10-6 Bertrand and Fishtrap Creeks
10-7 Wiser Lake-Tenmile Area
10-8 Lower Trib. Nooksack River
Wash-NP-Fraser-11
11-1 Upper South Tributaries
11-2 Saar Creek
11-3 Sumas River
WATERSHED BOUNDARY
10 MILES
NOOKSACK-SUMAS BASINS
GENERALIZED LAND USE MAP
LOCATION MAP

FIGURE 7-1

AGRICULTURE

PRESENT STATUS AND POTENTIAL

The Nooksack-Sumas Basins occupy most of the western portion of Whatcom County. The eastern portion of the Basins is mountainous. Of the total land area of 792,000 acres, those lands outside the national forest and national park boundaries have been mapped by a medium-intensity soil survey. Lands within the national forest and national park have been mapped by a low-intensity soil survey suitable for reconnaissance use. The 516,000 acres of land mapped with a medium-intensity survey contain 287,500 acres classified in Land Use Capability Classes II through VI.

These 287,500 acres of land have the greatest potential for development, i.e., changed use or improved use. Land Use Capability Classes II, III, IV are suited for either crop or urban uses, and Class VI has potential for urban development.

The Nooksack is the largest river in these Basins and drains an area of 760 square miles into Bellingham Bay. The Sumas drains 52 square miles into the Fraser River, and the Upper Chilliwack River drains 186 square miles of area, also into the Fraser River system in British Columbia. Coastal streams, such as California, Dakota, and Terrell Creeks, drain an area of 259 square miles directly into the Strait of Georgia.

Production

Farming and forestry are the main users of land in the Basins. Forage production in support of a livestock industry is the largest type of farming. There are large amounts of berries produced, both strawberries and raspberries, and a limited acreage of potatoes, usually used for seed. These crops, together with small acreages of canning peas and corn, create a diversity of farming enterprises. Total value of farm production is over $25 million annually.

The bench terrace and bottom land areas of the Nooksack-Sumas Basins provide the largest area of land suited for cropland within the Puget Sound Area. The equable marine climate is conducive to the production of a wide variety of crops. The productive potential of the area is great, but flood and drainage conditions make works of improvement necessary before this region reaches its full inherent potential.

Flooding

Climatic conditions are such that two periods of high runoff usually occur annually; one in the fall or winter as a result of excessive precipitation, and the other in early summer as a result of snowmelt. Occasionally this rapid runoff results in flooding of considerable areas of land in the Basins.

Many of the farmlands have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions will be discussed in the Means to Satisfy Needs section.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV. Principles and conditions discussed therein apply to the Nooksack-Sumas Basins and need not be repeated here.

Watersheds

Descriptions of the watersheds within the Nooksack-Sumas Basins follow. The numbers used identify the watersheds on the Land Use Map, figure 7-1, and on the Land Capability Map, Figure 7-2.

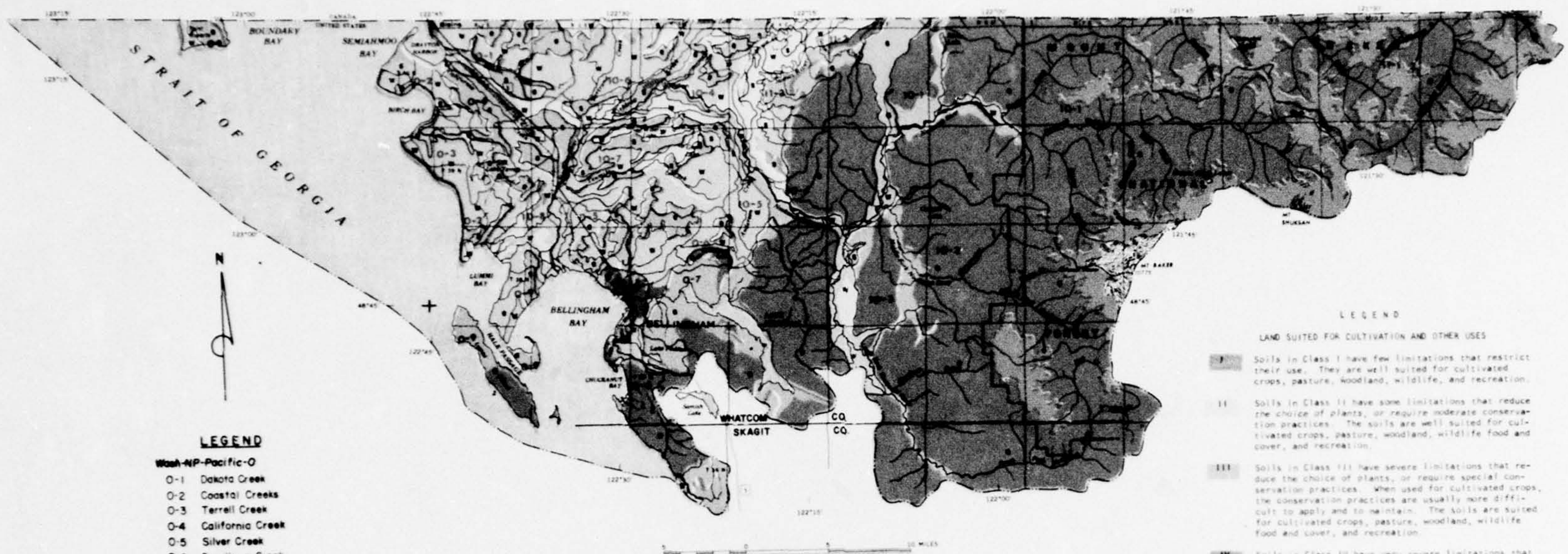
The North Fork Nooksack (10-1), the Middle Fork Nooksack (10-2), and the South Fork Nooksack (10-3), are, for the most part, mountainous watersheds largely devoted to the production of forest products. There is an area of good farmland in the lower portion of the South Fork Nooksack watershed.

The Middle Nooksack Tributaries (10-4), Anderson Creek (10-5), Bertrand-Fishtrap Creeks (10-6), Wiser Lake-Tenmile Creek (10-7), and the Lower Nooksack Tributaries (10-8) contain the farmlands of the Nooksack River system. The nearly 70,000 acres of developed farmlands in these watershed are suitable for further development to reach their potential.

The watershed designated as Upper South Tributaries (11-1) contains the Chilliwack River tributaries and is largely a timber producing region with a potential for timber products industries.

Saar Creek (11-2) and Sumas River (11-3) contain well-developed farming areas with a potential for still greater development to reach their potential.

Watersheds of the coastal areas are: Dakota


STRAIT OF GEORGIA
BOUNDARY BAY
SEMIAHMOO BAY
BIRCH BAY
LUMMI BAY
BELLINGHAM BAY
CHUCKANUT BAY
BELLINGHAM
WHATCOM
SKAGIT
CO.
CO.
N
NOOKSACK - SUMAS BASINS
GENERALIZED LAND CAPABILITY MAP
Class and Subclass
LEGEND
Wash-NP-Pacific-O
0-1 Dakota Creek
0-2 Coastal Creeks
0-3 Terrell Creek
0-4 California Creek
0-5 Silver Creek
0-6 Squalicum Creek
0-7 Lake Whatcom
0-8 Chuckanut Mountain
0-9 Lummi Island
Wash-NP-Nooksack-10
10-1 North Fork Nooksack River
10-2 Middle Fork Nooksack River
10-3 South Fork Nooksack River
10-4 Middle Trib. Nooksack River
10-5 Anderson Creek
10-6 Bertrand and Fishtrap Creeks
10-7 Wiser Lake-Tenmile Area
10-8 Lower Trib. Nooksack River
Wash-NP-Fraser-11
11-1 Upper South Tributaries
11-2 Saar Creek
11-3 Sumas River
WATERSHED BOUNDARY
LEGEND
LAND SUITED FOR CULTIVATION AND OTHER USES
I Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.
II Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
III Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
IV Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.
LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION
V Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.
VI Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.
VII Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.
VIII Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.
PRIMARY SUBCLASSES
e-Potential erosion or past erosion damage, sediment source
w-Wetness, poor drainage or overflow
s-Shallowness, stoniness or low moisture-holding capacity, etc.


LOCATION MAP

FIGURE 7-2

Creek (0-1), Coastal Creeks (0-2), Terrell Creek (0-3), California Creek (0-4), Silver Creek (0-5), and Squalicum Creek (0-6). All of these watersheds contain moderate acreages of farmland, most of which will require further development to reach its full potential. Urbanization is expected to encroach on some of these lands.

Lake Whatcom (0-7), Chuckanut Mountain (0-8), and Lummi Island (0-9) are largely in timber and their potential is for timber production or urban development on suitable areas within the watersheds.

Many of the farmlands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions are summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the Nooksack-Sumas Basins is shown in Table 7-1. The following tables are to indicate the potential development possible within acceptable land use standards.

Table 7-2 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-3 shows the number of acres in each capability class, subclass, and unit, by watershed, in the Nooksack-Sumas Basins. This table can be used with the description of capability units to estimate the potential for development.

TABLE 7-2. Distribution and value of production by crops in Nooksack-Sumas Basins

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	3,390	3,892	2.83	187,788	1.23
Field crops	1,989	2,283	1.66	681,800	4.45
Vegetables	4,977	5,713	4.16	1,226,010	8.01
Berries	1,886	2,165	1.57	2,228,617	14.56
Nursery products	147	169	.12	294,783	1.93
Cropland not used	4,037	4,635	3.37	--	--
Sub-Total	16,426	18,857	13.71	4,618,998	30.18
Hay	41,448	47,582	34.61	2,230,258	14.57
Hay aftermath	--	--	--	1,848,079	12.07
Sub-Total	41,448	47,582	34.61	4,078,337	26.64
Silage (grass)	13,294	15,261	11.10	1,011,052	6.61
Grass aftermath	--	--	--	592,725	3.87
Sub-Total	13,294	15,261	11.10	1,603,777	10.48
Silage (corn) fodder	2,666	3,061	2.23	202,796	1.32
Pasture (cropland)	45,934	52,731	38.35	4,801,173	31.38
Sub-Total	103,342	118,635	86.29	10,686,083	69.82
Total	119,768	137,492	100.00	15,305,081	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.

TABLE 7-3. Land capability units in Nooksack-Sumas Basins (acres)[1]

Sheet 1 of 4

Line	Capability units 2/	WATERSHEDS 10-1	10-2	10-3	10-4	10-5	10-6	10-7	10-8	11-1	11-2
1	II ws 02		3	234	40		88	35	3,065		554
2	II ws 03	38		1,401	2,225		431	1,601	515		2,192
3	II ws 04	11		1,706	232		614	1,100	1,185		477
4	II ws 06	51	32	270	352	21	2,535	4,420	744		93
5	II so 01			13		84	363	736			
6	II TOTAL	100	35	3,624	2,849	105	4,031	7,892	5,509		3,316
7	III ew 01	756	34	95	384	10	201	585	719	61	26
8	III es 02										
9	III we 16				191	108	1,001	1,501	999		
10	III ws 01	393	78	2,620	2,361	170	651	1,236	1,408		3
11	III ws 02	289	191	217	232						
12	III ws 03								149		
13	III ws 08				5	482	6,495	4,123	2,411		
14	III ws 09	218	11	62	188	138	361	74	814	8	68
15	III ws 10	390	151	542	797	1,398	1,885	3,097	1,026	24	293
16	III ws 11						132	79			
17	III ws 12	67			248	343	126	960	755		3
18	III so 01	110		314	117		1,378	854	23		
19	III so 08	263		32	299	217	2,138	1,456	76		
20	III TOTAL	2,486	465	3,882	4,822	2,866	14,368	13,965	8,380	93	393
21	IV ew 12			38	1,281	1,595	817	5,523	1,644		
22	IV ew 14	211	14	300	273	727		8	95	39	806
23	IV ew 22			21	8			10	453		
24	IV es 06	1,828	589	1,365	440		162	1,443	193	49	218
25	IV es 09						77	121	10		
26	IV es 13	63	80	1,787						8	
27	IV ws 01			221							
28	IV ws 02	192		20	268		80	357			5
29	IV ws 06	101	38	196	123	17	1,514	794	250	6	136
30	IV ws 10			32							
31	IV ws 11							120			
32	IV so 01	5,843	151	694	122	207	1,474	4,210	1,930	24	134
33	IV se 05			22	300	455	669	2,656	290		6
34	IV sw 06						9				
35	IV TOTAL	8,238	872	4,696	2,815	3,001	4,802	15,242	4,865	126	1,305
36	II-IV TOTAL	10,824	1,372	12,202	10,486	5,972	23,201	37,099	18,754	219	5,014

TABLE 7-3. Land capability units in Nooksack-Sumas Basins (acres)[1] (continued)

Sheet 2 of 4

WATERSHEDS											Line
11-3	0-1	0-2	0-3	0-4	0-5	0-6	0-7	0-8	0-9	Total	
1,317		42	36	37	236			17		5,704	1
7,280	68			7	64			8		15,830	2
1,580					94		3	163		7,165	3
1,471	187	341	232	781	211	129	150	58	19	12,097	4
	126				713					2,035	5
11,648	381	383	268	825	1,318	129	153	246	19	42,831	6
277	845	3,003	1,452	27	73	34	468	26	2,410	11,486	7
	215	26			14					255	8
154	2,042	119	821	1,719	1,429	1,612	29		37	11,762	9
1,196	107			370	429		22			11,044	10
616							143	46		1,734	11
		151			153			23		476	12
	5,249	462	925	3,097	216	8			93	23,566	13
53	351	3,749	1,833	229	139	8	185	44	255	8,788	14
1,038	1,644	1,490	1,531	1,342	1,755	3,411	2,139	569	1,383	25,905	15
	250			29	66					556	16
86	499	953	657	831	835	1,062	752	380	276	8,833	17
1,530	145	992	164		48		180		173	6,028	18
266	1,290			189	193					6,419	19
5,216	12,637	10,945	7,383	7,833	5,350	6,135	3,918	1,088	4,627	116,852	20
1,760	2,285	414	406	2,490	3,405	6,916	516	852	65	30,007	21
1,264	566	114	346	24		410	6,038	3,187		14,422	22
10	15	786	191	76			106	441	598	2,715	23
2,288	1,636	845	352			99	846	376	2,370	15,099	24
	191			62			489	946		1,896	25
							60			1,998	26
										221	27
174										1,096	28
957	82	226	9	110	10		67	125	24	4,785	29
262							68			362	30
	262			345		126		237		1,090	31
690	871	1,010	6	1,771	274	465				19,876	32
8	241			252	43				28	4,970	33
										9	34
7,413	6,149	3,395	1,310	5,130	3,732	8,016	8,190	6,164	3,085	98,546	35
24,277	19,167	14,723	8,961	13,788	10,400	14,280	12,261	7,498	7,731	258,229	36

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include land within national forest and park boundaries.
2/ See Exhibit 1 for description of capability units.

TABLE 7-3. Land capability units in Nooksack-Sumas Basins (acres)[1] (continued)

Sheet 3 of 4

Line	Capability units 2/	WATERSHEDS 10-1	10-2	10-3	10-4	10-5	10-6	10-7	10-8	11-1	11-2
1	V ws 21								114		
2	V TOTAL								114		
3	VI ew 21	945	306	1,464	51	260		177	26	38	567
4	VI ew 28			75	486	208	293	263	476		
5	VI es 18						251				
6	VI es 19	2,086	615	1,544	62		50	5	49	10	36
7	VI es 20	17	17	172	5	13	113	211			
8	VI es 22							6			
9	VI es 25							11			
10	VI ws 19	1,451	249	1,135	1,239			26			
11	VI so 10								81		
12	VI so 18			236							
13	VI se 13							235			
14	VI se 17			117							
15	VI TOTAL	4,499	1,187	4,743	1,843	481	707	934	632	48	603
16	VII ew 30				54						
17	VII ew 31					65		227			
18	VII es 29										
19	VII es 35										
20	VII es 36	49,921	29,425	78,958	10,757	2,244				4,856	3,993
21	VII ws 20			2							
22	VII TOTAL	49,921	29,425	78,960	10,811	2,309		227		4,856	3,993
23	VIII ew 39								2		
24	VIII ws 00	522	175	479	591	27	6	39			
25	VIII ws 22	10	5	8				6	11		
26	VIII ws 23								322		
27	VIII ws		24								
28	VIII so 00										
29	VIII TOTAL	532	204	487	591	27	6	45	335		
30	V-VIII TOTAL	54,952	30,816	84,190	13,245	2,817	713	1,206	1,081	4,904	4,596
31	II-VIII TOTAL	65,776	32,188	96,392	23,731	8,789	23,914	38,305	19,835	5,123	9,610

TABLE 7-3. Land capability units in Nooksack-Sumas Basins (acres)[1] (continued)

Sheet 4 of 4

WATERSHEDS											
11-3	0-1	0-2	0-3	0-4	0-5	0-6	0-7	0-8	0-9	Total	Line
		106			9				11	240	1
		106			9				11	240	2
1,092	127	48	178	23		407	2,358	2,087		10,154	3
105	325	44	140	358	218	579		81		3,651	4
										251	5
329	453	254			63	405	282	65	440	6,748	6
20	242	47	128	23	67	65	424	729	8	2,301	7
								3		9	8
										11	9
44										4,144	10
		577	96		68				169	991	11
								110		346	12
										235	13
								14		131	14
1,590	1,147	970	542	404	416	1,456	3,064	3,089	617	28,972	15
29										83	16
						351				643	17
		159							53	212	18
		325				11			58	394	19
7,183						1,091	21,411	11,625	3,154	224,618	20
										2	21
7,212		484				1,453	21,411	11,625	3,265	225,952	22
		401							40	443	23
										1,839	24
		3			4		12		80	139	25
		15			37			26		400	26
										24	27
						47	87	114		248	28
		419			41	47	99	140	120	3,093	29
8,802	1,147	1,979	542	404	466	2,956	24,574	14,854	4,013	258,257	30
33,079	20,314	16,702	9,503	14,192	10,866	17,236	36,835	22,352	11,744	516,486	31

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include land within national forest and park boundaries.
2/ See Exhibit 1 for description of capability units.

PRESENT AND FUTURE NEEDS

Urban

Population in the Nooksack-Sumas Basins will increase from 77,300 persons in 1967 to over 168,700 by 2020, based on Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 33,565 acres presently in intensive and rural non-agricultural use should provide ample acreage for new intensive development to the year 2020 without encroachment onto the croplands of the Basins.

Cropland Needs

These Basins presently have 137,500 acres of cropland. It is expected that cropland will remain about the same until after the year 2000, and will increase slightly to about 139,000 acres by 2020. Percent increases needed by crops for the Puget Sound Area are shown in Table 2-15 Puget Sound Area, Agriculture section.

Protection and Development Needs

Table 7-4 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Nooksack-Sumas Basins is summarized under the topic "Program Implementation" immediately following "Forestry." A more complete description is found in Appendix XIV, Watershed Management.

TABLE 7-4. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	97,539	97,539	97,539
Watershed protection and rehabilitation[2]	acre	149,100	149,100	150,600
Drainage improvement	acre	55,378	92,297	123,062
Irrigation development[3]	acre	60,000	80,000	115,000
Water for irrigation[4]	ac.ft.	114,600	152,800	219,650

[1] A total of 135,118 acres in these Basins are subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated here.

[2] Includes 11,600 acres of rangeland.

[3] According to Appendix VII, Irrigation, there were 38,400 acres (using 73,344 acre-feet of water) irrigated in 1966. Irrigation Appendix projections show 58,400 acres irrigated by 1980; 78,400 acres by 2000; and 74,400 acres by 2020.

[4] Based on gross diversion requirements of 1.91 acre-feet per acre estimated by Irrigation Committee in Appendix VII, Irrigation.

FORESTS

PRESENT STATUS

The majority of the land in the Nooksack-Sumas Basins is forest covered with some 65%, or 532,900* acres, being classified as forest land (Table 7-5). Forests are located throughout the Basin areas, but are concentrated in the mountainous central and eastern portions where less land use conversion has occurred. Of the total forest land, approximately 40,000 acres is held in reserved status, principally within the North Cascades National Park and the Larrabee State Park. Classification of the remaining available forest land by resource zone indicates the following:

*Figure does not include non-forested lands commonly associated with forest areas.

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	152,700	31
Principal Forest	242,120	49
Upper Forest	83,150	17
Subalpine	14,980	3
Total available	492,950	100

TABLE 7-5. Nooksack–Sumas Basins. Area of forest land, in acres, by ownership and type

Cover Type or Land Class	Available								
	National Forest	Other Federal	State & County	Municipal	Indian	Private	Total Available	Unavailable	Total Avail.& Unavail.
Douglas-fir									
seedlings and saplings	1,450	--	2,410	--	--	6,890	10,750	540	11,290
poletimber	2,230	40	14,210	120	10	25,830	42,440	1,470	43,910
small young growth sawtimber	5,160	30	9,560	580	190	26,760	42,280	2,410	44,690
old growth and large young growth sawtimber	3,370	10	4,680	90	20	7,620	15,790	4,140	19,930
True fir–mountain hemlock,									
seedlings and saplings	280	--	1,040	--	--	5,230	6,550	740	7,290
poletimber	2,080	--	10	--	--	390	2,480	820	3,300
small sawtimber	10,610	--	150	--	--	1,440	12,200	4,360	16,560
large sawtimber	43,890	10	1,900	--	--	11,340	57,140	6,450	63,590
Western hemlock,									
seedlings and saplings	950	10	5,710	--	--	21,930	28,600	310	28,910
poletimber	1,370	--	4,830	--	--	6,870	13,070	520	13,590
small sawtimber	4,280	10	3,650	--	--	7,090	15,030	1,040	16,070
large sawtimber	30,860	30	10,260	--	--	21,920	63,070	1,800	64,870
Western redcedar									
seedlings and saplings	--	--	20	--	--	540	560	--	560
poletimber	1,020	--	10	--	180	1,300	2,510	70	2,580
small sawtimber	1,590	--	580	--	--	630	2,800	690	3,490
Lodgepole pine									
seedlings and saplings	--	--	30	--	--	60	90	--	90
poletimber	900	--	30	--	--	90	1,020	--	1,020
Sitka–Englemann spruce									
poletimber	--	--	--	--	20	--	20	--	20
small sawtimber	3,350	--	--	--	--	--	3,350	--	3,350
large sawtimber	1,340	--	--	--	--	70	1,410	--	1,410
White fir									
small sawtimber	450	--	--	--	--	--	450	--	450
SUBTOTAL, softwoods	115,180	140	59,080	790	420	146,000	321,610	25,360	346,970
Hardwoods									
seedlings and saplings	310	--	1,130	--	60	9,830	11,330	70	11,400
poletimber	480	40	10,490	820	1,220	73,800	86,850	530	87,380
small sawtimber	1,010	10	3,890	220	2,140	27,550	34,820	1,030	35,850
large sawtimber	--	--	--	--	10	40	50	--	50
SUBTOTAL, hardwoods	1,800	50	15,510	1,040	3,430	111,220	133,050	1,630	134,680
Nonstocked									
cutover	150	--	1,420	--	--	6,760	8,330	30	8,360
deforested by fire	1,160	10	560	--	--	3,210	4,940	170	5,110
SUBTOTAL, nonstocked	1,310	10	1,980	--	--	9,970	13,270	200	13,470
TOTAL, productive land	118,290	200	76,570	1,830	3,850	267,190	467,930	27,190	495,120
Subalpine	14,200	--	280	--	--	500	14,980	11,210	26,190
Noncommercial, rocky	9,110	--	390	--	--	540	10,040	1,580	11,620
TOTAL, unproductive land	23,310	--	670	--	--	1,040	25,020	12,790	37,810
TOTAL, all forested land	141,600	200	77,240	1,830	3,850	268,230	492,950	39,980	532,930

TABLE 7-6. Nooksack-Sumas Basins. Volume of sawtimber and Growing Stock, by ownership, on productive forest land

Species or Group	National Forest	Other Federal	State & County	Muni-cipal	Indian	Private	Total Available	Unavail-able	Total Available & Unavailable
	Available								
Sawtimber—Thousand board feet, International ¼-inch Rule									
Douglas-fir									
small sawtimber	79,430	480	162,130	8,990	2,210	411,850	665,090	29,710	694,800
large sawtimber	188,090	530	265,980	4,990	810	428,390	888,790	162,120	1,050,910
True fir—mountain hemlock									
small sawtimber	186,250	--	2,760	--	--	26,890	215,900	65,180	281 080
large sawtimber	2,701,530	670	120.150	--	--	676,010	3,498,360	335,650	3,834,010
Western hemlock									
small sawtimber	66,020	100	55,050	--	--	121,850	243,020	16,640	259,660
large sawtimber	1,619,520	1,490	544,760	--	--	1,129,140	3,294,910	97,250	3,392,160
Western redcedar									
small sawtimber	33,830	--	9,250	--	300	11,930	55,310	11,890	67,200
large sawtimber	1,180	--	30	--	300	2,050	3,560	110	3,670
Other softwood species									
small sawtimber	63,690	--	50	--	30	170	63,940	--	63,940
large sawtimber	77,370	--	50	--	40	4,280	81,740	--	81,740
SUBTOTAL, softwoods	5,016,910	3,270	1,160,210	13,980	3,690	2,812,560	9,010,620	718,550	9,729,170
Hardwoods									
small sawtimber	10,980	110	50,510	2,730	23,090	340,790	428,210	11,770	439,980
large sawtimber	630	30	10,930	6 40	1,700	73,350	87,280	570	87,850
SUBTOTAL, Hardwoods	11,610	140	61,440	3,370	24,790	414,140	515,490	12,340	527,830
TOTAL sawtimber, all species	5,028,520	3,410	1,221,650	17,350	28,480	3,226,700	9,526,110	730,890	10,257,000
Growing Stock—Million cubic feet									
Douglas-fir	48.7	0.2	78.0	2.5	0.6	153.1	283.1	34.9	318.0
True fir-mountain hemlock	522.3	0.1	22.2	--	--	127.1	671.7	72.5	744.2
Western hemlock	328.4	0.3	116.9	--	--	243.8	689.4	22.2	711.6
Other softwood species	69.7	--	3.7	--	0.3	7.3	81.0	4.8	85.8
SUBTOTAL, softwoods	969.1	0.6	220.8	2.5	0.9	531.3	1,725.2	134.4	1,859.6
Hardwoods	4.6	--	24.3	1.3	9.8	163.7	203.7	4.9	208.6
TOTAL growing stock, all species	973.7	0.6	245.1	3.8	10.7	695.0	1,928.9	139.3	2,068.2

The Nooksack-Sumas Basins contain 467,900 acres of commercial forest land capable of producing crops of industrial wood. These lands support a sawtimber inventory of 9.5 billion board feet, International ¼-inch Rule (Table 7-6). These figures represent 9.3% of the Puget Sound Area's commercial forest land and 9.4% of its sawtimber volume. Privately owned lands, located mainly in the western half of the Basin, make up some 57% of the commercial forest area. Large private holdings, mostly corporate, make up some 109,300 acres of the total with medium-sized holdings accounting for another 5,700 acres. The remaining 152,300 acres of private forest land is held in farms and other small miscellaneous holdings. Public forest land, located mainly in the central and eastern portions of the basins, include some 200,700 acres of commercial land. Ownership is approximately 58% National Forest 38% State and county, and 4% other miscellaneous public.

The Nooksack-Sumas Basins support a well-established forest products industry in the western fringe of the area, particularly around the deep-water port facilities of Bellingham Bay. Of some 27 wood products plants located in the Basin in 1964, 23 were located in or near the city of Bellingham, 2 at Eversen, and 1 each at Deming and Maple Falls. By industry grouping, 7 of these plants are designated as sawmills and planing mills, 5 as paper and allied products plants, 2 as plywood and veneer plants, and 13 as miscellaneous products plants. While no output or employment data is available for these individual plants, it is estimated that their raw material needs exceed 257 thousand board feet daily at capacity.

Problems affecting forest land management and industrial development in the Nooksack Basin are typical of those found throughout the Puget Sound Area. Possibly the major problem affecting forest land managers is the development and use of the mountainous eastern half of the Basin. This area contains much steep, glaciated terrain which is highly unstable. The harvest of timber from these lands will be difficult and costly.

Problems affecting the forest products industries are quite typical of those previously discussed for the Puget sound Area as a whole.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

No determination of the demand for wood products is made specifically for the Nooksack-Sumas Basins. The nature of the forest products industries, particularly the relative ease of log transportation between basins, would make such a determination rather meaningless. In addition, a specific figure would imply that a production goal was established for the area, which is not the case. Production goals are established for the Puget Sound Area as a whole, with the assumption that considerable shifts in production between the basins will occur, depending upon the actual pattern of industrial and land use development.

For sake of basin comparison, however, there is some value in showing the percentage of demand that may be supplied by the Nooksack-Sumas Basin in the future. In 2020, the Basins are expected to contain about 10% of the commercial forest land in the Puget Sound Area. The percentage in earlier periods is slightly lower. It is, therefore, assumed that the basin will supply approximately 10% of the total wood products demand in the future.

The effect of competing uses for forest lands is discussed in detail in the section covering the Puget Sound Area. The estimated diversion of forest land from these causes in the Nooksack-Sumas Basins is shown below:

Type of Land Diversion	Acres Diverted (2020)
Parks, Wilderness, Campgrounds, or other Recreation Use	3,430
Roads and Highways	12,300
Urban-Industrial Development	24,250
Reservoirs, Powerlines, and other miscellaneous conversion	500
Private Land Use Reservations	15,960
Total	56,440

The current and prospective changes in the commercial forest land base from all causes are given below:

Current and projected commercial forest area in the Nooksack-Sumas Basins 1965-2020 (in thousand acres)

	Ownership						
	Private			Public			
Period	Large	Medium	Small	NF	Other Federal	Other	Total
1965	109.3	5.7	152.1	118.3	0.2	82.3	467.9
1980	113.4	5.7	137.2	117.4	0.2	81.2	455.1
2000	122.8	5.6	110.5	116.2	0.2	79.9	435.2
2020	126.4	5.5	85.9	114.9	0.2	78.6	411.5

Specific measures for soil and water protection are discussed in Appendix XIV, Watershed Management.

Summary

The Nooksack-Sumas Basins will increase in total number of people from 77,300 as of 1967 to 168,700 by 2020. Commercial forest lands are expected to lose 56,400 acres to roads, camps, parks, urban, and cropland by 2020. Total overall consumption of wood products will rise necessitating greater yields per acre.

PROGRAM IMPLEMENTATION AGRICULTURE AND FORESTS

In order to adequately provide for the needs of the Nooksack-Sumas Basins, as discussed on preceding pages, the following plan has been devised. This plan, multipurpose in scope, will provide for watershed protection and rehabilitation, the reduction of floodwater damage, drainage improvement, and irrigation development. Other measures provide for water quality and quantity control, recreation, and wildlife development.

This plan contains programs and projects to accomplish specific objectives of conservation and development. They provide for the full development of lands presently used for farming. It is planned that such lands will continue in their present use, and that approximately 1,500 acres will be added to present cropland by 2020.

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000); and (c) distant future (2000-2020).

Program measures are onsite practices which take advantage of improvements made possible by the structural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures include seeding of improved grasses and legumes, cover crops, drainage developments, forest management, irrigation developments, and many others. The total cost of the program for the early action period is $45,188,000.

There are eight early action projects proposed in Appendix XIV, Watershed Managment, for the Nooksack-Sumas Basins. The primary agricultural benefits from these projects are attributed to prevention of floodwater damage and improvement of drainage. The eight projects are expected to cost $614,200 annually, and to result in annual benefits of $2,269,000 annually, for a benefit-to-cost ratio of 3.7 to 1.

For the period between 1980 and 2000, seven projects, installation cost $5,950,000, are proposed; and five projects costing $936,000 will be installed after the year 2000. Program costs are expected to be $56,118,000 for the period after 1980, and $49,735,000 for the period after 2000.

Total cost of the plan is expected to be $168,840,000.

A summary of the early action projects is given in Table 2-21 in the Puget Sound Area section on agriculture. A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, Watershed Management, Nooksack-Sumas Basins section.

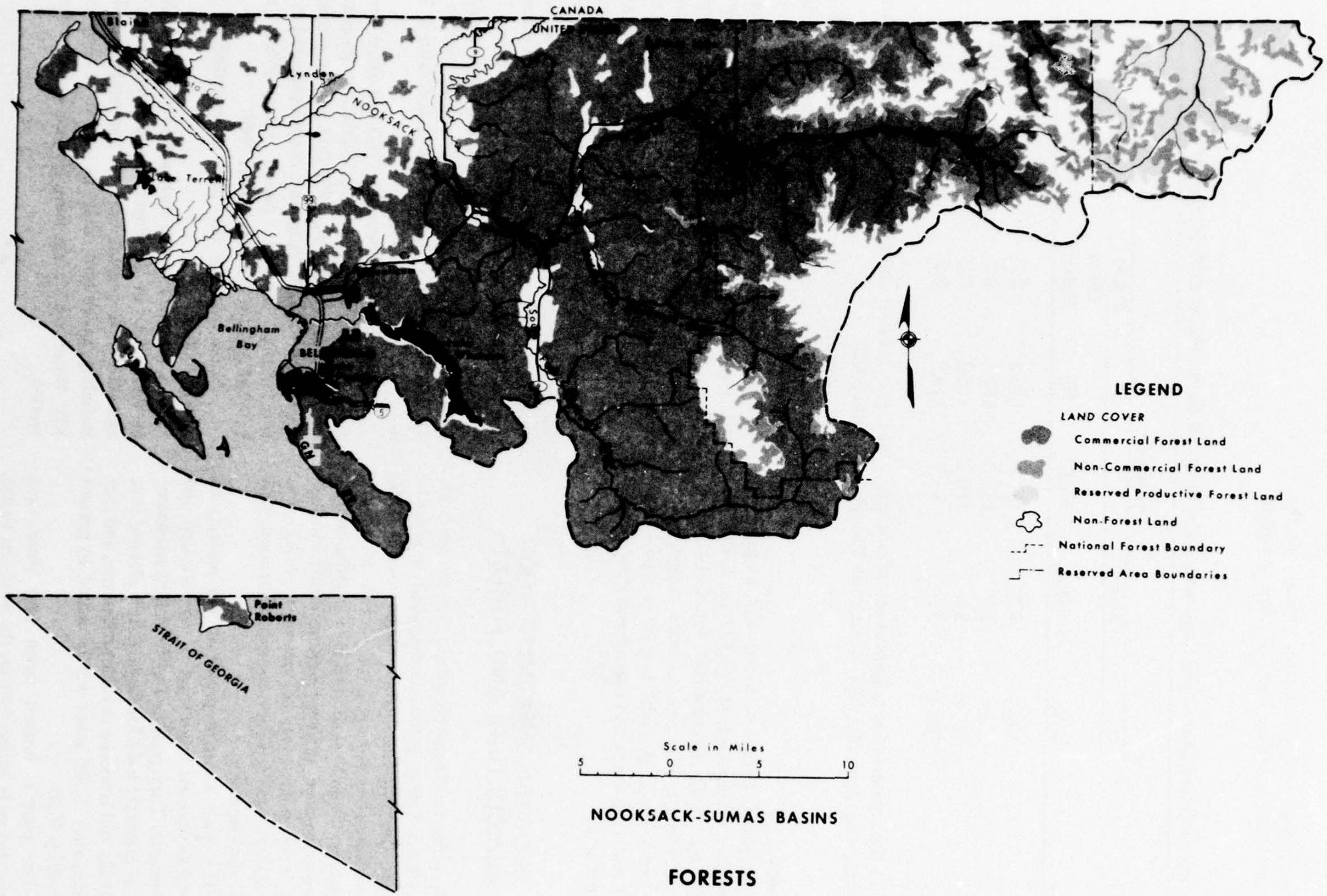


FIGURE 7-3. Forest lands in the Nooksack-Sumas Basins

MINERALS

The locations of the known mineral deposits in the basins are shown in Figure 7-4. The open circles on the map indicate properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

The Nooksack-Sumas Basins are important olivine and limestone producing areas. Other minerals that are or have been produced in quantity during the past are sand and gravel, building stone, coal, clay, silica, and gold. A few tons of chromite and copper ore have been produced for testing purposes, and small amounts of silver, lead, zinc, and peat also have been produced. Other mineral deposits that have been found in the area contain diatomite, nickel, and iron as their principal values.

Limestone

Limestone occurs as pods, lenses, and beds in the argillites and graywackes of the Chilliwack Group of Paleozoic age. Most of the deposits are located on Sumas, Red, and Black Mountains near Kendall, and Church Mountain near Glacier, all in northern Whatcom County.

Since 1926, the limestone has been used primarily by the pulp and cement industries of Whatcom County. Production figures that are available between 1919 and 1958 (first production began in 1912) show that about 2.5 million tons of limestone has been used. Production figures subsequent to 1958 are not available for publication.

Reserves are estimated to be well over 100 million tons, most of which is contained in Kendall, Sumas Mountain No. 2, and Black Mountain deposits. Both the Sumas Mountain No. 2 and Black Mountain deposits are undeveloped. There are several other limestone deposits in the more remote and inaccessible parts of the Nooksack-Sumas Basins that apparently are very large, but as yet, they have not been examined in detail, and no estimate of tonnage can be given. At present (1966), all production is coming from the Kendall and Silver Lake No. 1 deposits. The limestone from the Silver Lake deposit is being used primarily in the pulp industry, and the Kendall deposit is the source of raw material used at a cement plant in Bellingham, and has been for many years.

A summary of limestone reserves is as follows: 3 deposits contain over 10 million tons each, 2 deposits contain between 1 and 10 million tons, 4 deposits contain between 10,000 and 1 million tons, and 17 deposits contain less than 10,000 tons, or their size is not known.

Olivine

The largest olivine deposit in the United States—the Twin Sisters olivine—is literally a mountain of ore—the Twin Sisters Mountains—and covers an area 4 miles wide by 10 miles long. Three companies are currently (1966) producing olivine from the deposit, and it appears that the market for the material is increasing steadily. From 1957 to 1958, production increased 110 percent; from 1958 to 1959, 44 percent; from 1959 to 1960, 44 percent; from 1960 to 1961, 50 percent; from 1961 to 1962, 34 percent; and from 1962 to 1963, 44 percent. In the short period of time in which olivine has been mined from the Twin Sisters deposit, it is estimated that more than a million dollars worth of material has been taken out. Reserves are estimated at 160 billion tons, which, for all practical purposes, is an unlimited supply for all present and future needs.

Coal

The coal-bearing rocks in Whatcom County are about 12,000 feet thick. Stratigraphically, the two principal coal seams are more than 10,000 feet apart, with the Blue Canyon coal at the base and the Bellingham coal near the top. Several lesser seams occur in the intervening rocks.

The areal extent of the various beds is not accurately known; however, approximate bounds have been established. The thickness of the seams ranges from a few inches to 14 feet. The Bellingham No. 1 coalbed has an average thickness of 14 feet, but only the upper 7 or 8 feet has been mined. The Bellingham No. 2 bed, 2 feet in thickness, was found about 100 feet below the No. 1 seam. The coalbed mined at Blue Canyon ranges in thickness from an inch or so to 12 feet and is reported to average 7 feet. Three other coalbeds, each about 2 feet thick, occur above the main seam. In the Glacier field, where the coal is anthracite, the beds vary in thickness from a few inches to several feet, pinching and swelling rapidly within a short distance. Other coalbeds have been found in isolated outcrops and drill holes

MINERAL PROPERTIES IN NOOKSACK-SUMAS BASINS*

Explanation for Figure 7-4

Metallic Minerals
(with production or reserves data where available)

Chromium (30 properties)
- 12 – Danny
- 12A – Industrial Mining Co.
- 11 – Ribbon

Copper (3 properties)
- 8C – Glacier
- 8 – Silver Tip (prod.–27 tons)

Gold (17 properties)
- 1 – Boundary Red Mountain (prod.–$851,000)
- 6 – Evergreen
- 4 – Gargett
- 7 – Goat Mountain
- 2 – Gold Basin
- 3 – Gold Run
- 9 – Great Excelsior (prod.–$20,276)
- 5 – Lone Jack (prod.–$550,000)
- 10 – Nooksack

Iron (4 properties)
- 4C – Church Mountain (reserves–18 million tons)
- 4A – Lynden (reserves–30,000 tons)
- 4B – Sumas Mountain (reserves–750,000 tons)

Nickel (2 properties)

Silver (1 property)

Zinc (1 property)

Nonmetallic Minerals
(with reserves data where available)

Asbestos (1 property)

Coal (reserves–303.82 million tons)

Common clay (4 properties)
- 6 – Bellingham
- 5 – Brennan
- 3 – Everson
- 11 – Grandview

Diatomite (3 properties)

Olivine (reserves–160 billion tons)
- 8 – Northwest Olivine Co.
- 7 – Olivine Corp.
- 9 – Pacific Olivine Co.

Refractory clay (5 properties)
- 2 – Denny-Renton
- 1 – Sumas

Silica (1 property)
- 4 – Olympic

Special clay (1 property)

Stone Deposits

Limestone

Reserves
- Less than 10,000 tons (17 properties)
- 10,000 to 1 million tons (4 properties)
- 1 million to 10 million tons (2 properties)
- More than 10 million tons (3 properties

Sandstone (5 properties)

Volcanic rock (4 properties)

*Some properties not plotted on map because of poor description of location and/or lack of space.

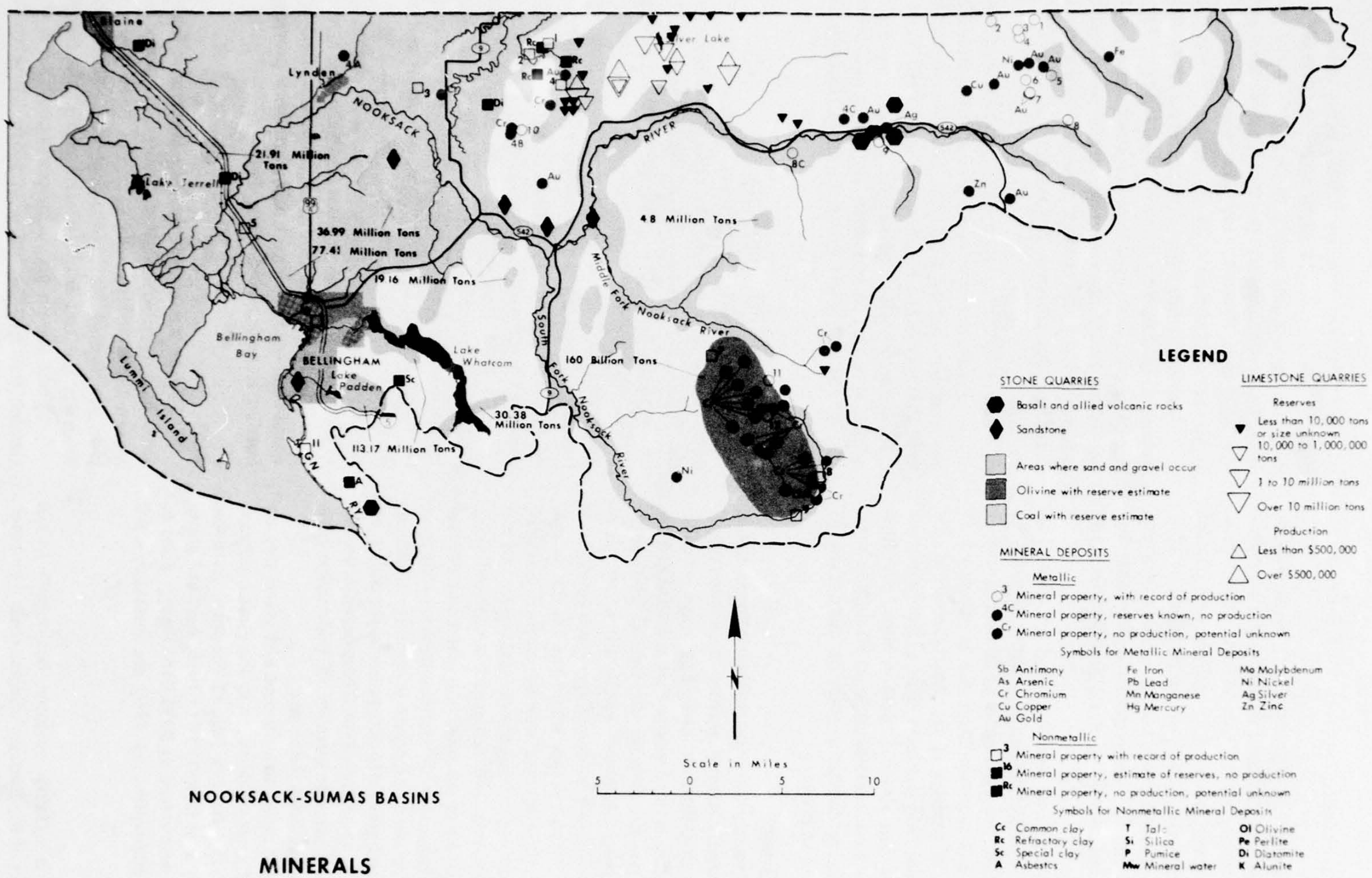


FIGURE 7-4. Mineral resources in the Nooksack-Sumas Basins

throughout the county, but very little is known of them.

The Bellingham coal seam was discovered in 1852, and the first coal mine in the State was opened on it the following year. From 1853 to 1955, when production ended, about 5.75 million tons of coal was taken from this bed. Two other mines, at Blue Canyon and at Glen Echo, had production of about 380,000 and 65,000 tons, respectively. Probably less than 1,000 tons of anthracite was produced from the Glacier field.

Remaining coal reserves total at least 303 million tons. The Bellingham coal seam, probably the most important, has a minimum of 50 million tons of bituminous coal reserves. There are in excess of 77 million tons of reserves in the Bellingham field, the Lake Whatcom field has more than 113 million tons, Glacier field has about 5 million tons, the Blue Canyon coal zone contains at least 30 million tons, and other fields contain a total of more than 78 million tons of reserves.

Sand and Gravel

The western part of the Nooksack-Sumas Basins contains relatively small quantities of sand and gravel suitable for construction uses. The most valuable material comes from deposits that were formed by melt-water streams flowing off the Vashon continental ice sheet. Although glacial till is ordinarily considered unfit as a source of aggregate, good gravel is so scarce that in places where the till has a high pebble content, it has been washed, crushed, and used for concrete and bituminous aggregate. Gravel terraces, river bars, and deltaic deposits found along the Nooksack River are small and commonly contain so many fragments of deleterious material that their suitability for use in aggregate is often questionable.

Sand and gravel deposits in the upper Basins are derived from alpine glaciation. These deposits usually contain a considerable quantity of undesirable rock fragments which limit their usage.

All told, more than 40 sand and gravel pits are known, and most of them are in the glacial outwash deposits of the western part of the area. Available figures show that from 1951 to 1960, sand and gravel production was valued at $915,976. Figures prior to 1951 and subsequent to 1960 are unavailable for publication.

Clay

Clay is a fairly common commodity in the western part of the Nooksack-Sumas Basins; however, only two pits are currently (1966) being operated. Most of the clay is glacial in origin and varies in thickness from a few inches to over 200 feet. Five refractory clay deposits in the Kendall area are associated with bedrock. One other special clay, an impure nonswelling bentonite, also occurs.

Material from the two operating pits, the Brennan (Fig. 7-4, No. 5) and the Everson (Fig. 7-4, No. 3), is used as an ingredient in making cement and for making heavy clayware, respectively. No estimate as to the total of past production or potential reserves is available for common clay except that the values are large.

Three of the refractory clay pits have a record of past production. Complete production figures are not available, but an estimated 53,418 tons worth $151,000 was mined between 1922 and 1949. In all, total refractory clay reserves are probably near 1.5 million tons. Little is known about the bentonitic clay except that where exposed it has a thickness of about 7 feet.

Stone Other Than Limestone

The Nooksack-Sumas Basins have one of the most unusual and attractive building stones found in the Puget Sound Area. This is the Shuksan stone, which is quarried for its rich green color. It is a chlorite-rich andesite that has good resistance to weathering and, as such, is used for facing on buildings, fireplaces, and wherever rock stability is important. There are four quarries, two from which this material is presently (1966) being taken.

All other rock quarries, both abandoned and producing, are in massive sandstone of the Chuckanut Formation. The sandstone is used primarily as riprap for flood control along the Nooksack River and as jetty stone and salt water riprap in the Bellingham Bay area. Two such quarries were in operation in 1965, although, as can be seen on Figure 4-3, several other quarries have a record of production. One old abandoned quarry along Chuckanut Drive provided building stone during the early days.

Peat

Fifteen major peat deposits comprising 6,616 acres have been investigated. Other large areas are known to be underlain by peat, but these have not been investigated. Most of the bogs are located on the relatively flat area in the western part of the Basins.

There are no producing peat operations at the present time (1966), but total production over the

years has amounted to $40,000, with practically all of the production consisting of sphagnum peat from Mosquito Lake. Peat reserves are sufficient to take care of the basin's demands for many years.

Silica

One silica deposit occurs and was first discovered in 1897; the land was patented in 1912. In 1935, the deposit was opened by Olympic Portland Cement Co., and for 12 years thereafter, the silica was used as an additive in manufacturing a low-temperature cement, most of which was used in the construction of the Grand Coulee Dam. Although some assays on the silica have run as high as 96.98 percent, the average, arrived through extensive sampling and assaying, is only about 90 percent SiO_2. Reserves are estimated at 50,000 tons. Production figures are not available for publication.

Diatomite

Three diatomite deposits are known, none of which appear to be commercial. Excess of organic matter, small size, and thick overburden present obstacles that make the deposits economically unattractive. No estimate as to reserves is available.

Gold

The Boundary Red Mountain mine (Fig. 7-4, No. 1) has been the most important gold-producing property. The mine, located in northcentral Whatcom County, was developed on a quartz vein that averages from 2 to 3 feet in width, but varies from less than 1 foot up to 7 feet. The trend of the vein is irregular, varying from N 40 E to N 13 E, and it dips from 50 to 60 degrees to the southwest. The wallrock is a dense, fine-grained diorite, separated from the vein by a thin parting of gouge. The gold is finely divided and free and is usually not visible to the unaided eye. Approximately 56,700 tons of ore was taken from the property between 1912, when production was first reported, and 1947, when the last production was recorded. During this time, operation of the property was intermittent. The ore averaged $15 a ton, and total production was about $581,000. Other minerals occurring in the vein are pyrite, chalcopyrite, pyrrhotite, and tetradymite. Silver values were not reported as being important.

The Lone Jack mine (Fig. 7-4, No. 5) operated between 1902 and 1924. Free gold with minor amounts of gold telluride occurs in a quartz vein that is traceable for some 2,500 feet. The average width of the vein is 30 inches, but pay zones are localized, and only portions of the vein carry commercial ore. The country rock is a schist. The ore is reported to have contained 2.5 ounces of gold per ton, and total production was valued at $550,000.

The Great Excelsior mine (Fig. 7-4, No. 9) operated during the early part of the century, and by 1915, when the last production was reported, the net return was $20,276. The ore deposit is a sulfide-cemented brecciated greenstone with quartz-dolomite gangue that occurs along the contact of an intrusive body. There are two mineralized zones, the largest of which was a maximum width of 75 feet. Ore minerals are pyrite, chalcopyrite, arsenopyrite, galena, sphalerite, tellurides, and native silver. The ratio of gold to silver in the ore is about 1 to 30.

Fourteen other gold properties are known; six (Fig. 7-4, No. 2,3,4,6,7, and 10) of these are reported to have made test shipments of one form or another.

Nickel

There are two reported nickel properties (Fig. 7-4), neither of which has produced any ore. Both deposits are the "nickel ledge" type, occurring in silica-carbonate rocks.

Probably the best possibility for the recovery of nickel is from the Twin Sisters olivine. Nickel assays on the olivine range from 0.143 percent to 0.612 percent with an average value of 0.254 percent. At present (1966), no detailed work has been done on the nickel-rich areas of the olivine mass. If the olivine were to be dissolved in a process used to recover magnesium chloride, possibly the nickel could be recovered as a byproduct.

Silver

Silver has been produced only as a byproduct of gold mining. The only silver property, the Tooker-Lestrud, is near the Excelsior mine. The mineral deposit consists of a pyrite zone up to 25 feet wide in metamorphosed volcanic and sedimentary rocks. The silver values are carried in the pyrite.

Zinc

No zinc has been produced, and only one property, the Chain Lakes, has been staked for its zinc content. The ore deposit consists of disseminated sulfides in brecciated limestone, greenstone, schist, and volcanic rock. Principal sulfides are sphalerite, chalcopyrite, pyrite, and bornite.

Oil and Gas

No oil has been produced. Exploration has been limited, as most companies have directed most of their exploration efforts to other parts of the State.

There has been a small amount of subcommercial gas production. This has come from an area just to the northwest of Bellingham, where the gas has been recovered from Pleistocene glacial deposits. Apparently the gas was generated in the coal seams of the underlying Chuckanut formation and migrated up into the glacial drift, where it was trapped. Locally, the gas has been used to heat outbuildings (barns, etc.,) that are located on the property from which the gas was recovered. The gas is produced from shallow depths (170 ± feet) and was first discovered by water welldrillers.

Copper

Although no significant amount of copper has been produced, one property, the Silver Tip (Fig. 7-4, No. 8), made a 27-ton shipment in 1947. However, before the operators were able to get into regular production, a snowslide destroyed the mine mill. Four and one-half tons of ore were shipped from the Glacier property in 1951.

Three properties are known to have copper as their principal value. All the known copper deposits are either small replacement bodies or fissure and vein deposits that have developed along shear zones.

Chromium

Most of the chromium deposits occur as chromite segregations or lenses in the Twin Sisters dunite mass. However, two deposits north of the Twin Sisters are associated with serpentinized rocks. Test shipments have been made from the Danny (Fig. 7-4, No. 12) and Ribbon (Fig. 7-4, No. 11) properties, which are located on Twin Sisters Mountain, but there has been no significant production from the properties.

The Industrial Mining Co. (Fig. 7-4, No. 12A) made shipments in 1959 from its property on the south flank of Twin Sisters Mountain, but production statistics are not available for publication. The ore occurs as chromite segregations in lenses in serpentine and dunite.

At least 30 chromite prospects are known.

Iron

Four iron properties are known, but none of these have produced. The Sumas Mountain deposit (Fig. 7-4, No. 4B) is a laterite that developed on rocks of pre-Tertiary age. The Church Mountain deposit (Fig. 7-4, No. 4C) was formed by the deposition of iron-rich material in a marine environment. The other two deposits, the Ruth Mountain and Lynden (Fig. 7-4, No. 4A), have pyrite and limonite (bog ore), respectively, as their ores. Reserve calculations for the Sumas Mountain deposit show 750,000 tons of 25 percent iron to be present. Reserves at Church Mountain are estimated at 18 million tons of material containing about 20 percent iron. The Lynden deposit contains about 30,000 tons of 30-percent iron. An estimate of reserves at Ruth Mountain is not available.

INTENSIVE LAND USE

Intensive land uses are mostly found in the western third of the Basins. Of the nearly 804,000 acres in the Nooksack-Sumas Basins, it is estimated that slightly over 20,896 acres are devoted to intensive uses at the present time. Within the Basins, there are seven (7) incorporated municipalities. These cities have a total population of 44,635, or well over one-half of the total population of Whatcom County. The bulk of intensive land uses in the Basins are to be found within the boundaries of these incorporated places. Much of the remainder of the intensive land use is located in close proximity to these cities and towns. It is composed of lands which are urban or industrial in character, but as yet remain unincorporated. Other developments are scattered throughout the Basins consisting of scattered settlements, farmsteads and rural non-farm residences. Considerable development also is to be found along the shores of the Strait of Georgia, mostly either full or part-time residences.

INCORPORATED CITIES AND TOWNS

Bellingham

The city of Bellingham is the major urban

settlement in the Nooksack-Sumas Basins. It was formed in 1903 by the consolidation of the existing towns of Fairhaven and New Whatcom, whose combined population in 1900 was 11,062 persons. Bellingham has experienced slow but steady growth since its formation.

Bellingham's population in 1920 was 25,585 persons, by 1967 the city had a population of 36,500 persons for a net increase of some 11,000 persons during the 47-year period.

The city is located at the western edge of the Nooksack-Sumas Basins, bordering the shores of Bellingham Bay. Principally a lumbering center in the past, this activity has continued to play a major role in the city's economy. More recently, other activities have increased in importance, most notable was expansion of water-borne commerce activities, substantial growth at Western Washington State College, and the addition of an oil refinery and an aluminum plant west of Bellingham at Ferndale.

Intensive land uses extend a considerable distance beyond the present city boundaries as a result of suburban development. Particularly to be noted is the development occurring around Lake Whatcom to the east of the city and along the shores of Bellingham Bay to both the north and south of the present city limits.

Lynden

The city of Lynden is located approximately 15 miles north of Bellingham and just a few miles south of the United States–Canadian border. The 1967 estimated population of Lynden is 2,850 persons, an increase of some 1,600 over the 1920 population of 1,200 residents. The economy of the city centers around the processing of agricultural products which are produced in the Basin. Aside from some minor scattered development, mainly rural non-farm residences in the environs of Lynden, most of the intensive land use in the area is centered in and around the city itself.

Ferndale

The city of Ferndale was incorporated around 1910 with a population of approximately 700 residents. Growth was very slow in the first three decades of its existence, but from 1940 on has been more substantial. By 1960, Ferndale's population was 1,442 and in 1967, it had grown to be an estimated 1,850 residents. As noted above, the recent establishment of an oil refinery and an aluminum plant in the vicinity has affected population growth in the city. Ferndale is located to the northwest of the city of Bellingham and borders on the Nooksack River approximately four miles from its outlet in Bellingham Bay.

Blaine

The city of Blaine in the northwest corner of the Nooksack-Sumas Basins immediately adjacent to the United States–Canadian border serves as the principal gateway for the Puget Sound Area from the United States to western Canada. The 1967 estimated population of Blaine is 1,775 persons. Since 1940, the city has experience relative stability, while during the period from 1910 to 1940, there was a loss of several hundred persons from Blaine's population. Other than serving as a gateway to Canada, the principal activities of Blaine are associated with its location on Drayton Harbor which includes terminal and moorage facilities for both small boats and seagoing vessels.

Sumas

The city of Sumas is located northeast of Bellingham immediately adjacent to the United States–Canadian border. Sumas has a 1967 population estimated at 674 persons. Since 1930, the population has remained fairly constant. Between 1910 and 1930, Sumas experienced a population decline of several hundred persons.

Everson

The city of Everson is located approximately 18 miles northeast of Bellingham. The 1967 estimated population of Everson is 625 persons. The city was incorporated around 1930 and has had a population increase of several hundred persons since that time.

Nooksack

The city of Nooksack is located immediately adjacent to Everson. Incorporated in 1920 with a population of around 200 persons, Nooksack has had a relatively stable population up to the present time. The 1967 estimated population of Nooksack is 361 persons.

Unincorporated Places

In addition to the incorporated cities discussed above, the Nooksack-Sumas Basins contain approximately 30 unincorporated places. These range in size

from those containing but a few persons to several loosely knit communities of several hundred persons. While the total acreage consumed by such places is not significant, the impact of these communities on the Basin's land resources often is significant. Of particular concern are those developments surrounding major urban centers. Due to the general nature of development in unincorporated territory, a great deal of land can be effectively committed to, or dominated by, intensive land uses, while only a small portion of land is actually utilized for these purposes. Because of this developmental characteristic, it is often difficult, if not impossible, for non-intensive uses to make beneficial and efficient use of large land areas near urban centers.

TRANSPORTATION

Rail–The area is served by the Great Northern, Northern Pacific, and the Milwaukee Railroads.

Highways–Interstate Highway 5 starts at Blaine and crosses the Basins from north to south through Bellingham. The area is served by a network of State and county roads.

Navigation–This area has an established harbor in Bellingham Bay. Bedload detritus from the Nooksack River is filling the bay at an alarming rate. New deepwater ports are being developed on the Strait of Georgia.

Airways–There are numerous small airfields for civilian us in this basin and a large municipal airfield at Bellingham.

LAND USE CHARACTERISTICS

Within the Nooksack-Sumas Basins there are 792,238 acres of land. This figure does not include acreages of inland (fresh) and saltwater which amounts to a little over 232,000 acres within the boundaries of the Basins. Table 7-1, contains the figures showing the various amounts of major land use acreages within the Basins.

Figure 7-1 portrays the arrangement of the present land use for the Nooksack-Sumas River Basins. From the map it can easily be seen the small amount of land that is now being put to intensive uses.

Intensive Land Use

At the present time (1967) intensive land uses occupy some 21,000 acres or 2.6 percent of the Basins' land area. Nearly all of the intensive land use areas are located within or near the Basins' incorporated and unincorporated communities. A few intensive uses can be found at scattered locations throughout the Basins, such as country stores, resorts, cemeteries, logging operations and similar use activities. The following list indicates the land use acreages for each of the intensive land use subgroups:

Railroads	Roadways	Airports	Urban (Built-up)	Total
613	5,177	294	14,812	20,896

Rural Non-Agricultural

Many of the land uses classified within the Rural nonagricultural category are similar in character and often associated with or the forerunners of intensive land use. The following list indicates the land use acreages for each of the Rural nonagricultural subgroups:

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm yards)	Total
3,720	4,324	658	3,967	12,669

The Rural Nonagricultural land use amounts to 13,000 acres of 1.6 percent of the total Basin's area. The reason for this inclusion of the Rural Nonagriculture data in this portion of the Appendix is that the Rural Nonfarm Residences, and the Farmstead subgroups both contain lands which are the forerunner of intensive land use, and will more than likely make this transition to intensive land use during the planning period.

Land Ownership

Of the total land area (792,238 acres) in the Nooksack–Sumas Basins, 37.6 percent is in private ownership; 17.2 percent in private corporate ownership; 34.1 percent in Federal ownership; 9.8 percent in State ownership; and 1.3 percent in local govern-

ment ownership. The bulk of the private corporate, Federal and State ownerships are forested areas located in the eastern two-thirds of the Basins. Land areas owned by local governments (city, county and special districts) are largely located in the western third of the Basins. These land areas are mainly related to intensive use consisting of streets, facilities, local parks and similar areas. Other private ownerships are also located primarily in the western third of the Basins and consist mainly of intensive, rural nonagricultural and agricultural land areas.

TRENDS AND POTENTIALS

Intensive land use in the Nooksack-Sumas Basins amounts to some 21,000 acres of approximately 2.6 percent of the total Basins' area. Intensive land use requirements are presently being filled in and around existing urban concentrations, mainly in the Bellingham area. Recent trends show a certain amount of new development on the shore of Puget Sound and in various locations bordering on Interstate 5. Within the Nooksack-Sumas Basins there are approximately seven (7) townships, comprising some 161,000 acres, which are considered most likely to receive pressure for conversion to intensive uses. This potential growth area is located mainly north and east of the present city of Bellingham. The Basins also contain approximately four additional townships of good agricultural land which should be protected from possible encroachment by intensive development.

PRESENT AND FUTURE NEEDS

Future needs for land for intensive uses have been determined by two major factors; the first being the projected population for the Basins, the second being the density at which this population settles on the lands. Present population in the Basins is 77,300, with a density pattern of 3.6 persons per acre in the intensive land use areas. Population in the Basins is projected to increase to 168,700 by the year 2020, with an intensive land use density 5.5 persons per acre, resulting in a total of 29,800 acres of land being put to intensive uses. With 161,000 acres of land deemed likely and suitable for future conversions and only 30,000 acres actually needed to satisfy the intensive land use needs to the year 2020, there is a real need to guide new development to those lands which are best suited for intensive uses, and to those areas where land use change will cause the least conflict between uses competing for land. Figure 7-5 shows the generalized future land use pattern (C_2) for the year 2020 in the Nooksack-Sumas Basins.

Industrial land use needs are projections of the type of uses existing today. Future land needs will come from the pulp and paper industry, wood products industry, aluminum industry and the oil industry. There will be a need for expansion and further development of a deep-water port facility within the Nooksack-Sumas Basins which will require an additional large plot of land. Since so many industries require water access, a special effort is needed by all concerned to plan for industrial sites in prime loations that do have water access, and the necessary adjacent lands to house today's and tomorrow's industries.

Recreation and tourism are major "industries" in the Nooksack-Sumas Basins, and both will have tremendous growth by the end of the planning period (2020). Both recreation and tourism facilities must be able to develop on an equal status with industrial development within the Basins. The Nooksack-Sumas Basins are just south of a major metropolitan center in Canada, and are just north of the multi-metropolitan center of Everett, Seattle-Tacoma and serves as a recreation area for both of these areas. This area, serving as a recreation area for these two large population centers, will demand an increase of recreation lands during the next fifty years. Special efforts are urgently needed in the years to come to assure a desirable environment in the Basins which are conducive to the development of recreation lands.

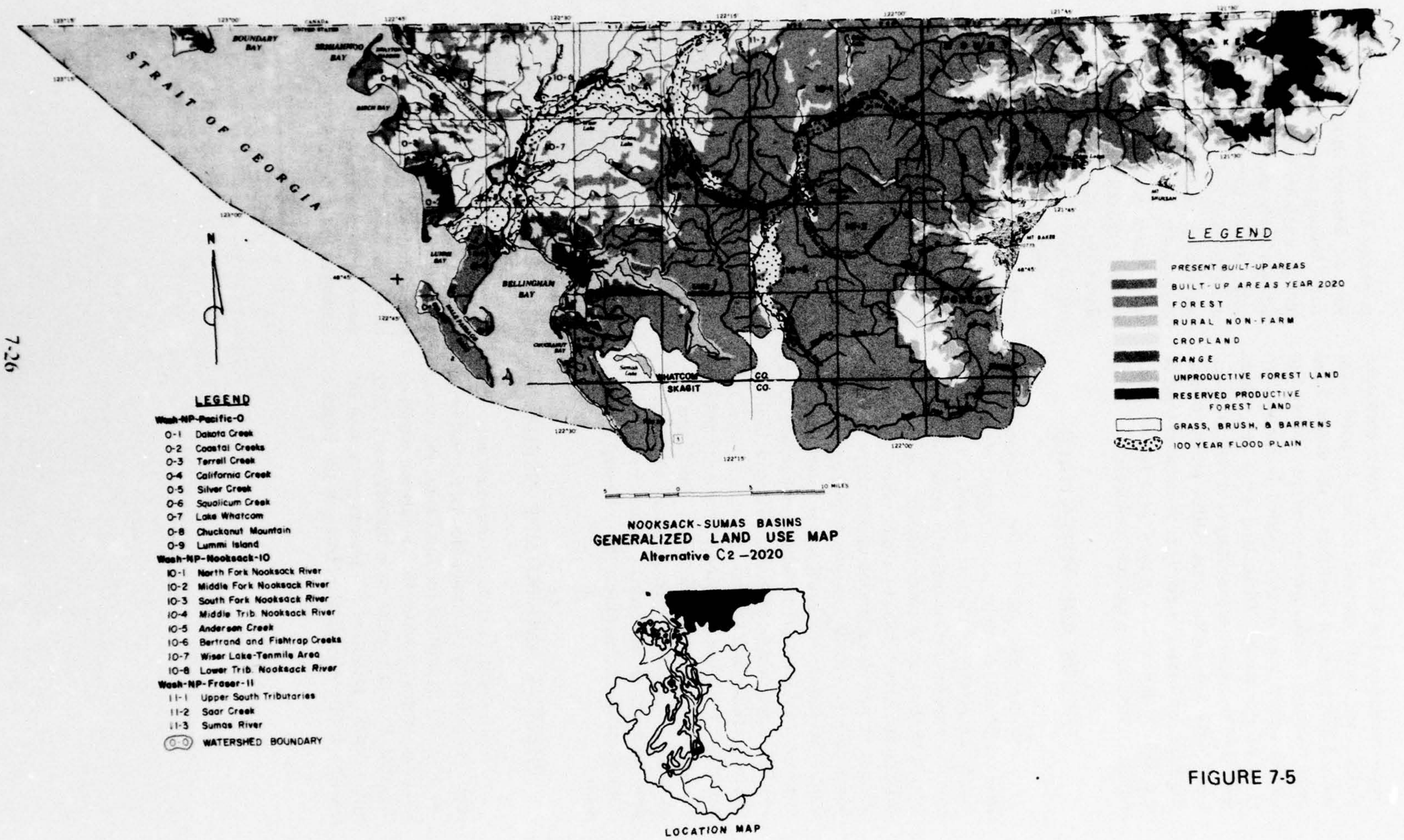
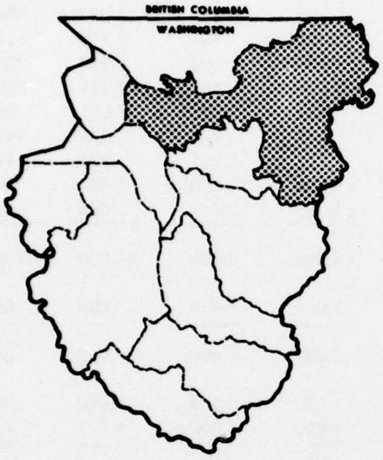

STRAIT OF GEORGIA
BOUNDARY BAY
SEMIAHMOO BAY
BIRCH BAY
BELLINGHAM BAY
WHATCOM CO.
SKAGIT CO.
N
LEGEND
PRESENT BUILT-UP AREAS
BUILT-UP AREAS YEAR 2020
FOREST
RURAL NON-FARM
CROPLAND
RANGE
UNPRODUCTIVE FOREST LAND
RESERVED PRODUCTIVE FOREST LAND
GRASS, BRUSH, & BARRENS
100 YEAR FLOOD PLAIN
LEGEND
Wash-NP-Pacific-0
0-1 Dakota Creek
0-2 Coastal Creeks
0-3 Terrell Creek
0-4 California Creek
0-5 Silver Creek
0-6 Squalicum Creek
0-7 Lake Whatcom
0-8 Chuckanut Mountain
0-9 Lummi Island
Wash-NP-Nooksack-10
10-1 North Fork Nooksack River
10-2 Middle Fork Nooksack River
10-3 South Fork Nooksack River
10-4 Middle Trib. Nooksack River
10-5 Anderson Creek
10-6 Bertrand and Fishtrap Creeks
10-7 Wiser Lake-Tenmile Area
10-8 Lower Trib. Nooksack River
Wash-NP-Fraser-11
11-1 Upper South Tributaries
11-2 Saar Creek
11-3 Sumas River
WATERSHED BOUNDARY
5 0 5 10 MILES
NOOKSACK-SUMAS BASINS
GENERALIZED LAND USE MAP
Alternative C2 –2020
LOCATION MAP

FIGURE 7-5

SKAGIT — SAMISH BASINS



The Skagit-Samish Basins are located in the north sector of Puget Sound Area, in parts of Whatcom, Skagit, and Snohomish Counties. The total hydrologic area is approximately 1,947,963 acres in the United States plus 256,330 acres in the Province of British Columbia, Canada. Major tributaries of the Skagit River include the Sauk and the Suiattle Rivers draining the Glacier Peak Area, and the Baker River, an important hydro-power stream. The Samish is a shorter stream in the northwest corner draining directly into salt water. The Skagit-Samish Basins are the largest in size in the Puget Sound Area and contain the greatest amount of forest land.

Population

The population of the basins in 1967 was 56,900 persons. This population is primarily located in the western portion of the basins. Projections show that the population will grow to 64,200 by 1980, 86,500 by 2000 and 118,200 persons by the year 2020. This growth will take place adjacent to the existing areas of development in the western portion of the basins.

Land Use

The primary land use in the Skagit-Samish Basins is forests and associated lands with approximately 90% of the total basins being put to this use. The other two major uses, croplands and urban or intensive land uses occupy 5% and 1% of the land respectively and are primarily located on the river flood plain in the western portion of the basins. Figure 7-6, the generalized land use map of the Skagit-Samish Basins, portrays the land areas occupied by each of the major uses.

TABLE 7-7. Land use in Skagit-Samish Basins (acres)[1]

Map No.	Watersheds	Crop-land	Range-land	Total Forest[2]	Rural Non-agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
9-1	Upper Skagit River	1,561	3,896	692,781	3,448	669	14,130	716,485
9-2	Baker River	111	246	181,676	10	188	6,693	188,924
9-3	Cascade River	80	--	116,508	750	137	1,146	118,621
9-4	Suiattle River	50	40	221,319	--	166	1,762	223,337
9-5	Sauk River	775	330	240,049	2,639	653	2,221	246,667
9-6	North Skagit Tribs.	9,882	1,063	53,562	847	1,832	1,031	68,217
9-7	South Skagit Tribs.	2,476	641	110,815	516	591	2,375	117,414
9-8	Gages Slough	7,100	1,116	1,362	2,720	2,121	335	14,754
9-9	Nookachamps	7,480	2,593	34,740	1,668	1,096	1,461	49,038
9-10	South Mt. Vernon	11,500	1,520	14,881	1,788	2,443	485	32,617
	Total Skagit	41,015	11,445	1,667,693	14,386	9,896	31,639	1,776,074
0-14	Samish River	27,737	4,195	51,765	2,089	1,896	983	88,665
	Total Samish	27,737	4,195	51,765	2,089	1,896	983	88,665
0-10	Fidalgo Island Group	3,226	109	29,153	1,597	5,204	1,010	40,299
0-15	Skagit Flats	28,487	3,999	4,834	2,020	1,808	1,777	42,925
	Total Pacific Drainages	31,713	4,108	33,987	3,617	7,012	2,787	83,224
	Skagit-Samish Basins	100,465	19,748	1,753,445	20,092	18,804	35,409	1,947,963

[1] Unadjusted measurements, 1966, for Puget Sound Area Study.

[2] Figures include non-forested land commonly associated with forest areas.

AGRICULTURE

PRESENT STATUS AND POTENTIAL

The Skagit-Samish Basins are located largely in Skagit County, although the eastern portion of Whatcom County and the northeastern portion of Snohomish County are within the drainage basin.

Much of the area is mountainous. Of the total land area of 1,912,554 acres, those lands outside the national forest and national park have been mapped by a medium-intensity soil survey. Lands within the national forest and national park have been mapped by a low-intensity soil survey suitable for reconnaissance use. Of the 523,181 acres mapped with the medium-intensity survey, approximately 270,000 acres are classified in Land Use Capability Classes II through VI.

These 270,000 acres of land have the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, and IV are suited for either cropland or urban uses, and Class VI has potential for urban developments.

The Skagit is the largest river in the Puget Sound Area. It drains an area of 3,105 square miles, of which nearly 400 square miles are in Canada. The principal tributaries are the Sauk River and Baker River.

The Samish River and its tributary, Friday Creek, originate in the hills south of Bellingham and drain an area of 139 square miles. The general character is related to the Skagit.

Ten offshore islands are found in the Basins but their particular problems of drainage are distinct from the mainland.

The Skagit-Samish Basins provide the largest valley system in the Puget Sound Area. The system includes many flood and drainage problem areas which require corrective measures before their poten-

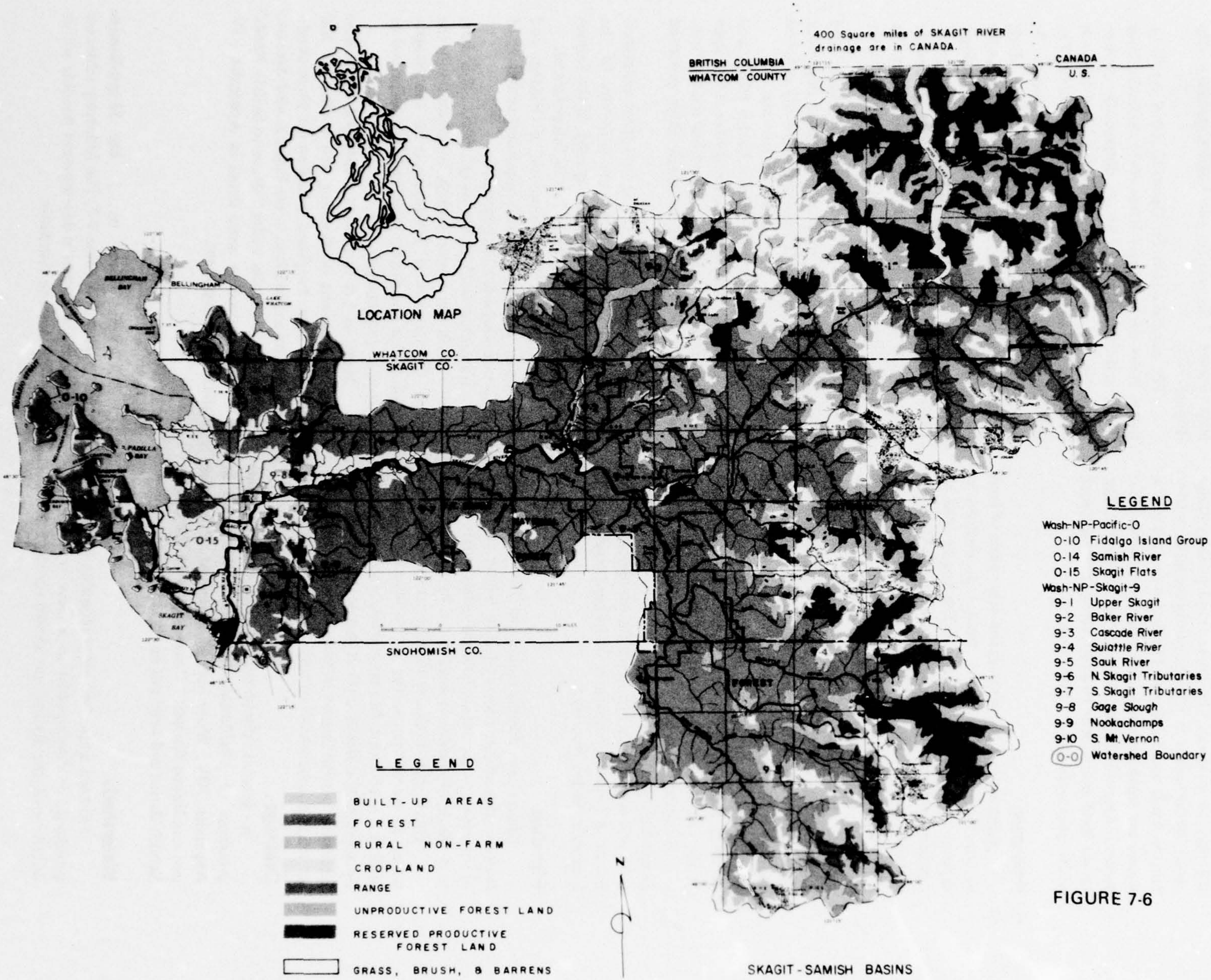


FIGURE 7-6

SKAGIT-SAMISH BASINS
GENERALIZED LAND USE MAP

tial may be attained. The lower flood plain contains about 90,000 acres of level or gently undulating river bottom lands and tidelands. The upper reaches of the Basins are steep, mountainous valleys with turbulent streams. Below Sedro Woolley the valley drops almost to sea level and widens to a flat, fertile plain as much as 20 miles wide and 20 miles long.

Production

Farming and forestry are the main users of land in the Skagit-Samish Basins. Forage production in support of a livestock industry is the largest type of farming. In earlier days much small grain was raised, and the area is said to hold the world's record for oats produced per acre. Grain production decreased as horses used for logging decreased in numbers with mechanization. Many farms produce significant amounts of vegetables, berries, and vegetable seeds. In fact, the area produces probably 90 percent of the cabbage seed and half of the garden beet seed for the United States, plus large amounts of turnip and rutabaga seeds. Despite these significant totals, most of the cropland is used to support the dairy industry.

Forestry continues as a major industry of the Skagit-Samish Basins and supports several large sawmills and wood pulp plants within or adjacent to the Basins. A large manufacturer of logging machinery is located at Sedro Woolley.

Flooding

Climatic conditions induce two flood-producing seasons annually, one in the fall or winter as a result of excessive precipitation, and the other in late spring as a result of snowmelt augmented by precipitation.

Discharges in excess of channel capacity cause water to spread across the valley where it remains until the river drops. In many areas, water is trapped by topographic detail until it can seep into the soil. Excessive rainfall causes similar flooding conditions, as well as swamping of the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV, Watershed Management. Principles and conditions discussed therein apply to the Skagit-Samish Basins and need not be repeated here.

Watersheds

Thirteen watershed areas requiring solutions to problems, or development to achieve potential productivity of the Basins, are shown on the Land Use Map (Figure 7-6), and on the Land Capability Map (Figure 7-7).

The watersheds of the Upper Skagit River (9-1), Baker River (9-2), Skagit River (9-3), Suiattle River (9-4), and Sauk River (9-5) are dominantly timber-producing areas and much of the land is within the boundaries of the Mount Baker National Forest. The federally-owned lands are managed by the U. S. Forest Service under the multiple-use concept. Much of the privately-owned forest is managed under sustained yield programs, and the general hydrologic characteristics of the area are rated as very good. These five watersheds are the main sources of summer flow in the Skagit River, as the higher elevation snowpack usually carries well into the summer season.

Watersheds (9-6), North Skagit Tributaries, and (9-7), South Skagit Tributaries, are more important from the farming aspect but are dominantly in forest use and their potential is largely for that use.

Gages Slough (9-8), Nookachamps (9-9), and South Mount Vernon (9-10) watersheds contain large acreages of high-producing cropland but require more development if they are to reach their potential productive capacity.

The farming area of the Samish River watershed (0-14) is very important to the economy of the Samish Basin. The productive capacity of the Samish watershed is high if developed to its full potential.

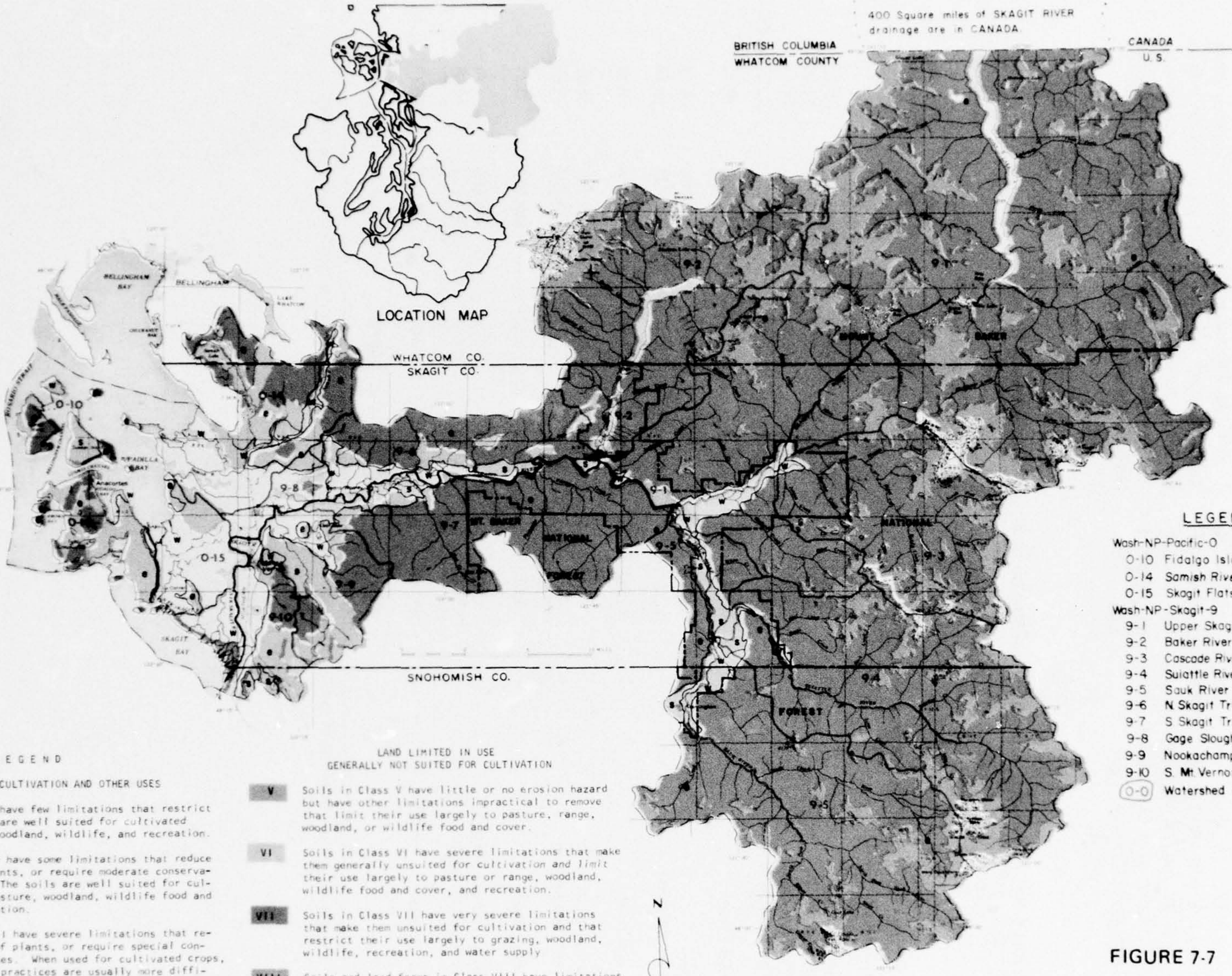
Watershed 0-10 is composed of Fidalgo and some other small islands. It is important as an area of possible development for urban use.

Watershed 0-15 is the Skagit Flats. This area, together with the Lower Samish, is economically the center of agricultural development in the Skagit-Samish Basins and further development is expected to increase its productivity.

Many of the farmlands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions will be summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs" and are discussed in more detail in Appendix XIV Watershed Management.

Tables

Generalized land use in the Skagit-Samish Basins is shown in Table 7-7. The following tables are to indicate the potential development possible within acceptable land use standards.



LEGEND

Wash-NP-Pacific-O
- 0-10 Fidalgo Island Group
- 0-14 Samish River
- 0-15 Skagit Flats

Wash-NP-Skagit-9
- 9-1 Upper Skagit
- 9-2 Baker River
- 9-3 Cascade River
- 9-4 Suiattle River
- 9-5 Sauk River
- 9-6 N. Skagit Tributaries
- 9-7 S. Skagit Tributaries
- 9-8 Gage Slough
- 9-9 Nookachamps
- 9-10 S. Mt. Vernon
- (0-0) Watershed Boundary

LEGEND

LAND SUITED FOR CULTIVATION AND OTHER USES

I — Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II — Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III — Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

IV — Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

V — Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

VI — Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

VII — Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

VIII — Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

SKAGIT-SAMISH BASINS
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

FIGURE 7-7

Table 7-8 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-9 shows the number of acres in each capability class, subclass, and unit by watersheds in the Skagit-Samish Basins. This table can be used with the description of capability units to estimate the potential for development

TABLE 7-8. Distribution and value of production by crops in Skagit-Samish Basins

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	3,037	3,406	3.39	164,313	.80
Field crops	1,070	1,200	1.19	358,372	1.75
Vegetables	25,770	28,907	28.77	6,203,590	30.22
Berries	2,023	2,269	2.26	2,335,794	11.38
Nursery products	2,909	3,263	3.25	5,691,586	27.73
Cropland not used	2,793	3,134	3.12	--	--
Sub-Total	37,602	42,179	41.98	14,753,655	71.88
Hay	18,882	21,180	21.08	992,755	4.84
Hay aftermath	--	--	--	892,234	4.35
Sub-Total	18,882	21,180	21.08	1,884,989	9.19
Silage (grass)	5,513	6,185	6.16	409,775	2.00
Grass aftermath	--	--	--	275,287	1.34
Sub-Total	5,513	6,185	6.16	685,062	3.34
Silage (corn) fodder	1,971	2,211	2.20	146,489	.71
Pasture (cropland)	25,594	28,710	28.58	3,054,527	14.88
Sub-Total	51,960	58,286	58.02	5,771,067	28.12
Total	89,562	100,465	100.00	20,524,722	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.

TABLE 7-9. Land capability units in Skagit-Samish Basins (acres)[1]

Sheet 1 of 2

Capability units 2/	WATERSHEDS													
	9-1	9-2	9-3	9-4	9-5	9-6	9-7	9-8	9-9	9-10	0-10	0-14	0-15	Total
II ws 02	13					766	13	1,084	574	2,747	355	3,706	7,261	16,519
II ws 03	943		10		609	5,183	1,393	5,618	2,570	1,574		4,454	4,708	27,062
II ws 04	557	12		55	430	1,046	906	1,030	1,879	3,393	873	10,961	15,358	36,500
II ws 06		116			15	75	10	3	395	488	268	693	6	2,069
II so 01	27			25		155	350				40	265		862
II TOTAL	1,540	128	10	80	1,054	7,225	2,672	7,735	5,418	8,202	1,536	20,079	27,333	83,012
III ew 01					30					332	977	257	4	1,600
III es 02	157					52		18	450	1,102	59	578		2,416
III ws 01	2,558		176	115	1,906	3,643	1,901	3,915	369	1,275		4,155	2,144	22,157
III ws 02	952	54	125	80	55	232	61		165	25	50	430		2,229
III ws 03											158	346	706	1,210
III ws 05	85											276		361
III ws 08					95					55				150
III ws 09		103			5	74	62	2	123	520	361	126	31	1,407
III ws 10	38				15	85	30		1,213	960	1,089	1,046	280	4,756
III ws 12											60	202	85	347
III so 01	333			45	671	2,642	1,814		165		59	1,251		6,980
III so 08	463		10		110	429	481		11		64	34		1,602
III sw 09		28				35			124	251		6		444
III TOTAL	4,586	185	311	240	2,887	7,192	4,349	3,935	2,620	4,520	2,877	8,707	3,250	45,659
IV ew 12	68					353		932	2,586	1,706	2,111	4,915	1,798	14,469
IV ew 14	65	239				533		219	2,283	183	686	3,481		7,689
IV ew 22		673				6	67	176	3,141	4,908	6,730	2,167	157	18,025
IV es 06	346	40		25		110						1,320		1,841
IV es 08						3,051	278		649					3,978
IV es 09	247			20	10	180		6	952	650	27	90	80	2,262
IV ws 01												5		5
IV ws 02	135		20				23							178
IV ws 03										23				23
IV ws 05								29		10			196	235
IV ws 06	8	60		5	55	13	15	18	177	366	105	1,286	59	2,167
IV ws 10	2					65	1,309		66			164		1,606
IV ws 11	72					547		321	1,688	960	3,578	4,588	4,322	16,076
IV ws 43												94		94
IV so 01	271				146	198	241		11	125	449	535	5	1,981
IV se 05					60					5	175		25	265
IV sw 09									343		1,895	3		2,241
IV TOTAL	1,214	1,012	20	50	271	5,056	1,933	1,701	11,896	8,936	15,756	18,648	6,642	73,135
II-IV TOTAL	7,340	1,325	341	370	4,212	19,473	8,954	13,371	19,934	21,658	20,169	47,434	37,225	201,806

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include land within national forest and park boundaries.

2/ See Exhibit 1 for description of capability units.

TABLE 7-9. Land capability units in Skagit-Samish Basins (acres)[1] (continued)

Sheet 2 of 2

Capability units 2/	WATERSHEDS 9-1	9-2	9-3	9-4	9-5	9-6	9-7	9-8	9-9	9-10	0-10	0-14	0-15	Total
V ws 21											6	33		39
V TOTAL											6	33		39
VI ew 21		2,087			20	374	357	30	2,773	1,449	944	2,654	47	10,735
VI ew 26						779	416		1,304					2,499
VI ew 28								82	125	197	132	631		1,167
VI es 19	82		75	205	1,234	3,259	1,052		390	524	182	1,330	20	8,353
VI es 20	145			75	390	317	252	7	1,174	700	20	15	165	3,260
VI es 22	951	721		25	1,065									2,762
VI es 25			60											60
VI es 27											2,441			2,441
VI ws 19	818		135	1,045	2,595	577	1,069	369	95	94	15	112	159	7,083
VI so 12	1,265	361		1,780	3,165		190							6,761
VI so 13		84					148							232
VI so 18	561	58	530	700	2,401	6,276	2,515	73	165	589	1,141	3,536	113	18,658
VI se 13	171	183		240	645									1,239
VI se 17		65				798	10	63	80	899	551	405		2,871
VI TOTAL	3,993	3,559	800	4,070	11,515	12,380	6,009	624	6,106	4,452	5,426	8,683	504	68,121
VII ew 30									1,509	260	98	76		1,943
VII ew 31						111		73	12	20		564		780
VII es 29	53				77	2,221	319		317		29	190		3,206
VII es 34						114	45		525					684
VII es 35	10					279			2,800	793	2,757	34		6,673
VII es 36	16,727	17,536	16,362	9,642	16,937	32,193	59,525	242	16,276	4,223	9,688	30,151	372	229,874
VII ws 20	162		75	65	100		33							435
VII so 23					780					325				1,105
VII TOTAL	16,952	17,536	16,437	9,707	17,894	34,918	59,922	315	21,439	5,621	12,572	31,015	372	244,700
VIII ew 39											429	75		504
VIII ws 00	448		115	105	958	351	1,119	104	68	31		25	49	3,373
VIII ws 23										355	450	367	2,598	3,770
VIII ws 24					60	44			30	15		2		151
VIII so 00		7				20		5			237	48	400	717
VIII TOTAL	448	7	115	105	1,018	415	1,119	109	98	401	1,116	517	3,047	8,515
V-VIII TOTAL	21,393	21,102	17,352	13,882	30,427	47,713	67,050	1,048	27,643	10,474	19,120	40,248	3,923	321,375
II-VIII TOTAL	28,733	22,427	17,693	14,252	34,639	67,186	76,004	14,419	47,577	32,132	39,289	87,682	41,148	523,181

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include land within national forest and park boundaries.

2/ See Exhibit 1 for description of capability units.

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the Skagit-Samish Basins will increase from 57,000 persons in 1967 to about 118,200 by 2020, according to Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 38,896 acres presently in intensive and rural nonagricultural uses could provide ample acreage for new intensive development to the year 2020 without encroachment onto the croplands of the Basins.

Cropland Needs

These Basins presently have 100,465 acres of cropland. It is expected that cropland will increase slightly in each of the three base time periods, reaching a level of 115,000 acres by 2020. Percent increases needed, by crops, for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Data in Table 7-10 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Skagit-Sumas Basins is summarized under the topic "Program Implementation" immediately following "Foresty." A more complete description is found in Appendix XIV, Watershed Management.

TABLE 7-10. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	90,439	90,439	90,439
Watershed protection and rehabilitation[2]	acre	120,748	124,748	134,748
Drainage improvement	acre	49,023	81,705	108,940
Irrigation development[3]	acre	40,000	60,000	95,000
Water for irrigation[4]	ac.ft.	76,800	115,200	182,400

[1] A total of 155,353 acres in the Skagit-Samish Basins are subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated here.

[2] Includes 19,748 acres of rangeland.

[3] According to Appendix VII, Irrigation, there were 6,200 acres (using 11,904 acre-feet of water) irrigated in 1966. Irrigation Appendix projections show 16,200 acres irrigated by 1980, 26,200 acres by 2000, and 51,200 acres by 2020.

[4] Based on gross diversion requirements of 1.92 acre-feet per acre, estimated by Irrigation Committee in Appendix VII, Irrigation.

FORESTS

PRESENT STATUS

1,754,000* acres, or some 75%, of the land in the Skagit-Samish Basins is covered by forests. Some 69%, or 976,080 acres, of the forest land is classified as available timber land. (Table 7-11). Forests are found in all portions of the Basins with the heaviest and most continuous timber stands in the central and eastern sections. Approximately 375,000 acres of forest land. is in a reserved classification located primarily in the North Cascades National Park and in the Paysaten and Glacier Peak Wilderness.

*Figure does not include nonforested lands commonly associated with forest areas.

The available timber land is divided into resource zones as shown below:

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	189,550	19
Principal Forest	573,870	59
Upper Forest	176,730	18
Subalpine	35,930	4
Total available	976,080	100

TABLE 7-11. Skagit-Samish Basins—Area of forest land in acres by ownership and type

Cover Type or Land Class	Available: National Forest	Available: Other Federal	Available: State & County	Available: Municipal	Available: Indian	Available: Private	Available: Total Available	Unavailable	Total Avail. & Unavail.
Douglas-fir									
seedlings and saplings	6,190	--	2,460	70	100	6,510	15,330	6,990	22,320
poletimber	13,070	20	12,740	350	350	31,490	58,020	2,930	60,950
small young growth sawtimber	46,570	120	11,100	920	1,020	37,410	97,140	6,970	104,110
old growth and large young growth sawtimber	65,910	110	4,010	240	180	14,720	85,170	24,370	109,540
True fir—mountain hemlock									
seedlings and saplings	1,040	--	2,140	--	--	11,840	15,020	2,970	17,990
poletimber	11,230	--	230	--	--	310	11,770	4,580	16,350
small sawtimber	27,090	--	510	--	--	790	28,390	23,770	52,160
large sawtimber	112,080	--	2,330	--	--	7,930	122,340	55,900	178,240
Western hemlock									
seedlings and saplings	6,050	--	3,600	--	--	18,330	27,980	2,480	30,460
poletimber	5,650	10	4,800	--	--	7,970	18,430	3,290	21,720
small sawtimber	18,730	60	3,590	--	70	14,720	37,170	11,050	48,220
large sawtimber	105,370	50	6,260	--	10	20,100	131,790	29,270	161,060
Western redcedar									
poletimber	--	--	120	--	--	850	970	--	970
small sawtimber	2,680	--	40	20	--	940	3,680	--	3,680
large sawtimber	17,480	--	80	--	10	1,640	19,210	2,980	22,190
Lodgepole pine									
seedlings and saplings	--	--	20	--	--	30	50	--	50
poletimber	4,830	--	--	--	20	--	4,850	--	4,850
small sawtimber	670	--	--	--	--	--	670	--	670
Sitka—Englemann spruce									
small sawtimber	3,360	--	--	--	--	--	3,360	--	3,360
large sawtimber	2,020	--	--	--	--	30	2,050	2,120	4,170
Ponderosa pine									
seedlings and saplings	--	--	40	--	--	--	40	--	40
Western white pine									
poletimber	2,020	--	--	--	--	--	2,020	--	2,020
White fir									
small sawtimber	890	--	--	--	--	--	890	--	890
large sawtimber	670	--	--	--	--	30	700	--	700
SUBTOTAL, softwoods	453,600	370	54,070	1,600	1,760	175,640	687,040	179,670	866,710
Hardwoods									
seedlings and saplings	1,660	10	1,250	120	30	12,080	15,150	30	15,180
poletimber	5,520	10	17,250	430	610	64,470	88,290	190	88,480
small sawtimber	4,120	10	6,160	50	750	41,550	52,640	890	53,530
large sawtimber	--	--	190	--	--	1,230	1,420	60	1,480
SUBTOTAL, hardwoods	11,300	30	24,850	600	1,390	119,330	157,500	1,170	158,670
Nonstocked									
cutover	3,900	--	2,270	--	30	2,900	9,100	--	9,100
deforested by fire	670	--	510	--	--	200	1,380	530	1,910
SUBTOTAL, nonstocked	4,570	--	2,780	--	30	3,100	10,480	530	11,010
TOTAL, productive land	469,470	400	81,700	2,200	3,180	298,070	855,020	181,370	1,036,390
Subalpine	43,010	--	620	--	--	470	44,100	78,040	122,140
Noncommercial, rocky	126,060	--	880	130	10	2,310	129,390	117,410	246,800
TOTAL, unproductive land	169,070	--	1,500	130	10	2,780	173,490	195,450	368,940
TOTAL, all forested land	638,540	400	83,200	2,330	3,190	300,850	1,028,510	376,820	1,405,330

The Skagit-Samish Basins contain 834,730 acres of commercial forest land capable of producing continuous crops of forest products. Sawtimber inventory on these lands is 23.6 billion board feet, International ¼-inch Rule (Table 7-12). The Basins contain 17% of the Puget Sound Area's commercial forest land and 23% of its sawtimber volume.

About 35% of the commercial forest area is privately owned. Large corporate holdings are 102,000 acres, medium-size holdings are 9,000 acres, with the remaining 189,000 acres of private forest land in farms and other miscellaneous small holdings. Public forest lands, located mainly in the central and eastern parts of the Basins, include 533,500 acres of commercial forest land. Ownership is 72% National Forest, 15% other Federal, 12% State and county and 1% municipal.

Logs and other forest products from the Skagit-Samish Basin are transported to manufacturing plants throughout the Puget Sound Area. However, deep water ports such as Everett, Bellingham, and Anacortes receive most of the material. Within the basins proper there are 12 sawmills, 2 plywood plants, and 1 paper mill. The 12 sawmills, located at Anacortes, Concrete, Hamilton, Mt. Vernon, Sedro Woolley, and Darrington, manufacture a variety of products such as hardboard, treated products, specialty products, box material, and veneer. Daily material needs exceed 600,000 board feet and during peak marketing periods may approach one million board feet at full plant capacity.

Problems affecting industrial development and forest land management in the Basins are the same as those for similar basins in the Puget Sound Area. Problems of the forest products industry, aside from price of raw material and fluctuation of markets for products, are related to expensive road access and construction and plant location that will conform with pollution controls and public acceptance.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

No determination of the demand for wood products is made specifically for the Skagit-Samish Basins. The nature of the forest products industries, particularly the relative ease of log transportation between basins, would make such a determination rather meaningless. In addition, a specific figure would imply that a production goal was established for the basins, which is not the case. Production goals are established for the Puget Sound Area as a whole, with the assumption that considerable shifts in production between the basins will occur, depending upon the actual pattern of industrial and land use development.

For sake of basin comparison, however, there is some value in showing the percentage of demand that may be supplied by the Skagit-Samish Basins in the future. In 2020, the Basins are expected to contain about 17% of the commercial forest land in the Puget Sound Area. The percentage in earlier periods is slightly lower. It is therefore assumed that the basin will supply approximately 17% of the total wood products demand in the future.

The effect of competing uses for forest lands is discussed in detail in the section covering the Puget Sound Area. The estimated diversion of forest land from these causes in the Skagit-Samish Basins is shown below:

Type of Land Diversion	Acres Diverted (2020)
Parks, Wilderness, Campgrounds, other Recreation Use	71,530
Roads and Highways	20,340
Urban–Industrial Development	7,800
Reservoirs, Powerlines, and other miscellaneous conversion	2,000
Private Land Use Reservations	24,010
Total	125,680

TABLE 7-12. Skagit–Samish Basins. Volume of sawtimber and growing stock, by ownership, on productive forest land

Species or Group	Available								Total Available & Unavailable
	National Forest	Other Federal	State & County	Municipal	Indian	Private	Total Available	Unavailable	
Sawtimber–Thousand board feet, International ¼-inch Rule									
Douglas-fir									
small sawtimber	702,850	1,720	182,610	14,550	12,400	567,000	1,481,130	85,110	1,566,240
large sawtimber	3,621,820	5,140	228,980	13,370	7,680	797,120	4,674,110	957,220	5,631,330
True fir–mountain hemlock									
small sawtimber	485,650	--	8,960	--	--	19,880	514,490	349,230	863,720
large sawtimber	6,908,850	--	148,130	--	--	477,330	7,534,310	3,387,290	10,921,600
Western hemlock									
small sawtimber	288,280	640	53,240	--	660	232,400	575,220	159,900	735,120
large sawtimber	5,531,710	2,480	334,770	--	410	1,036,830	6,906,200	1,529,110	8,435,310
Western redcedar									
small sawtimber	55,040	--	850	330	--	15,920	72,140	--	72,140
large sawtimber	1,564,240	--	5,940	--	710	101,360	1,672,250	239,970	1,912,220
Other softwood species									
small sawtimber	88,250	--	20	--	30	10	88,310	--	88,310
large sawtimber	202,130	--	30	--	30	2,750	204,940	119,750	324,690
SUBTOTAL, softwoods	19,448,820	9,980	963,530	28,250	21,920	3,250,600	23,723,100	6,827,580	30,550,680
Hardwoods									
small sawtimber	48,150	90	80,470	860	8,280	469,410	607,260	9,740	617,000
large sawtimber	5,950	10	25,700	380	620	102,470	135,130	2,410	137,540
SUBTOTAL, hardwoods	54,100	100	106,170	1,240	8,900	571,880	742,390	12,150	754,540
TOTAL SAWTIMBER, all species	19,502,920	10,080	1,069,700	29,490	30,820	3,822,480	24,465,490	6,839,730	31,305,220
Growing Stock–million cubic feet									
Douglas-fir	787.8	1.2	75.0	5.1	3.7	248.5	1,121.3	189.9	1,311.2
True fir–mountain hemlock	1,337.5	--	28.4	--	--	89.9	1,455.8	675.9	2,131.7
Western hemlock	1,134.0	0.6	75.6	--	0.2	247.3	1,457.7	329.1	1,786.8
Other softwood species	756.1	--	2.7	0.1	0.3	47.5	806.7	142.4	949.1
SUBTOTAL, softwoods	4,015.4	1.8	181.7	5.2	4.2	633.2	4,841.5	1,337.3	6,178.8
Hardwoods	21.4	0.0	42.0	0.5	3.5	226.0	293.4	4.8	298.2
TOTAL growing stock, all species	4,036.8	1.8	223.7	5.7	7.7	859.2	5,134.9	1,342.1	6,477.0

The current and prospective changes in the commercial forest land base from all causes are given below:

Current and projected commercial forest area in the Skagit-Samish Basins 1968-2020 (in thousand acres)

	Ownership						
	Private			Public			
Period	Large	Medium	Small	NF	Other Federal	Other	Total
1965	101.6	9.1	187.3	386.5	63.1	87.1	834.7
1980	106.9	9.1	172.8	322.1	61.3	85.6	757.8
2000	117.9	9.0	145.8	318.5	60.4	83.8	735.4
2020	121.8	8.8	122.9	314.1	59.6	81.8	709.0

PROGRAM IMPLEMENTATION AGRICULTURE AND FORESTS

In order to adequately provide for the needs of the Skagit-Samish Basins, as discussed on preceding pages, the following plan has been devised. This plan, multipurpose in scope, will provide for floodwater prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development. Other measures provide for water quality and quantity control, recreation, and fish and wildlife development.

This plan contains programs and projects in order to accomplish specific objectives of conservation and development. They provide for the full development of lands presently used for farming. It is planned that such lands continue in their present use with approximately 15,000 more acres added to cropland by 2020.

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000); and (c) distant future (2000-2020).

Program measures are onsite practices which take advantage of development made possible by the structural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management, and irrigation development. Total cost of the program for the early action period is $64,761,000.

There are four early action projects described in Appendix XIV, Watershed Management. Primary agricultural benefits from these projects are prevention of flooding and drainage improvement. The four projects are expected to cost $593,500 annually, and to result in annual benefits of $2,242,000 for a benefit cost ratio of 3.8 to 1.

Three projects with an installation cost of $1,850,000 are proposed for the period between 1980 and 2000; and five projects costing $1,460,000 will be installed after the year 2000. Program costs are expected to be $84,934,000 for the period after 1980 and $93,896,000 for the period after 2000. Total cost of the plan is expected to be $257,538,000.

A summary of the early action projects is given in Table 2-21 of the Puget Sound Area section on agriculture. A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, *Watershed Management, Skagit-Samish Basins* section.

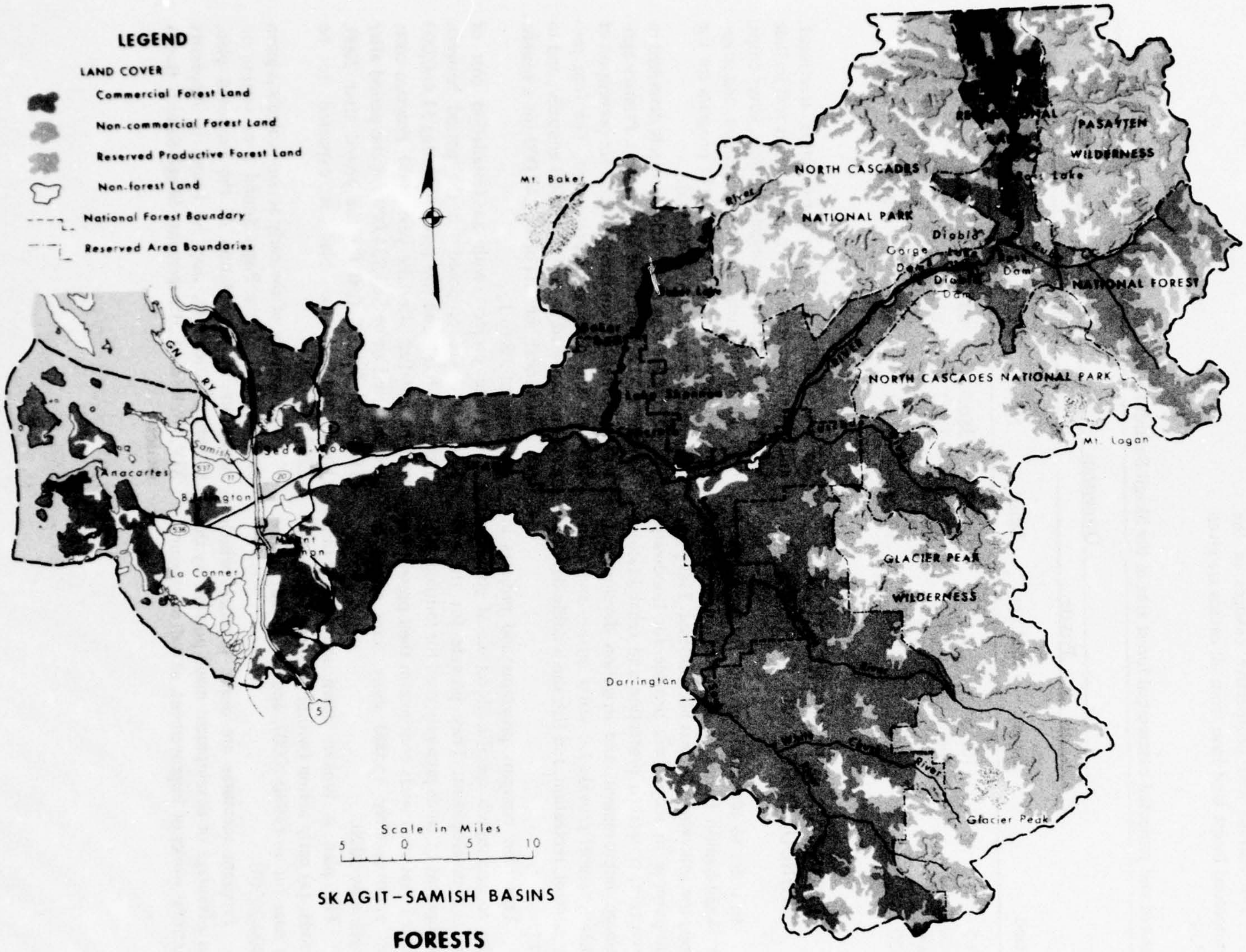


FIGURE 7-8. Forest lands in the Skagit-Samish Basins

MINERALS

The locations of the known mineral deposits in the basins planning are shown in Figure 7-9. The open circles on the maps indicate properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

The Skagit-Samish Basins have been an important limestone source for many years. It also is the only area in the Puget Sound region where talc, strontium, and asbestos have been produced. Other minerals and ores that have been or are being produced are sand and gravel, coal, clay, olivine, peat, silica, pumice, basalt, copper, gold, chromium, and iron. Small test shipments of lead have also been made. Other ore deposits in the area contain nickel, silver, zinc, manganese, and molybdenum. Nonmetallic minerals that occur in the area but which have had no production are mineral water and diatomite. Although rocks favorable for the occurrence of oil and gas occur, test wells drilled to date have not been productive.

Limestone

The limestone occurs as beds and lenses in predominantly thin-bedded siltstones and graywacke along with conglomerate, chert, and volcanic rocks of the Chilliwack Group. The deposits are located near Concrete in Skagit County, Dock Butte in Skagit and Whatcom Counties, and Circle Peak and Lime Mountain in Snohomish County.

The Concrete deposit was the first limestone deposit to be quarried, and the first one to be developed for manufacturing cement in Washington. Originally, a cement plant was put into production in 1907 at Concrete by the Washington Portland Cement Co. A short time later, Superior Portland Cement (now Lone Star Cement Corp.) built a plant at Concrete also. The Washington Portland Cement plant has been closed for years, but the Superior (Lone Star) plant had been in production continuously until 1968 when the plant was forced to shut down for economic reasons. Production figures are not available for publication; however, it is estimated that the deposit at Concrete has produced several million dollars worth of limestone since it was first opened. The only other deposit that has been quarried is the Three Mile Creek deposit, but production figures are not available for publication.

Limestone reserves are estimated at slightly more than 1 billion tons, most of which is contained in two deposits, the Concrete in Skagit County and the Lime Mountain in Snohomish County.

A breakdown of limestone reserves follows: 4 deposits with 10 million or more tons each, 3 deposits with between 1 and 10 million tons, 12 deposits with between 10,000 and 1 million tons, and 7 deposits with less than 10,000 tons, or whose size is not known.

Olivine

Two areas are potential olivine sources—Goat Mountain and Cypress Island (Fig. 7-9). One of the Cypresss Island deposits, Olivine Hill, has a record of past production. Olivine from this site was fused with phosphate rock to make fertilizer.

Reserves for the Goat Mountain area are estimated at 10 billion tons and for Cypress Island at 50 million tons.

Coal

Coal occurs in several areas. The major coal deposits are in the Hamilton, Cokedale, and Blue Canyon areas, and small deposits of unknown size occur in the McMurray area.

The coal measures in the extreme northwest part of the area are part of the Blue Canyon coal deposit and occur near the base of the Chuckanut Formation. The rest of the coal deposits are separated from the Blue Canyon area by a band of pre-Tertiary metamorphic rocks; however, the coalbeds in the Cokedale and Hamilton areas are probably the same age as the lowermost beds of the Blue Canyon coal. The Cokedale and Hamilton coals are probably continuous under the overlying Pleistocene glacial drift and Recent alluvium that appears to separate them. The position of the McMurray coal in the stratigraphic section is not definitely known.

The thickness of the coalbed that was mined in the Blue Canyon area varies from 0 to 12 feet but averages about 3 to 4 feet. The Cokedale coal varies from a few inches to almost 30 feet in thickness, but only about half of the 30 feet is reported as being usable coal. Thickness of beds in the Hamilton area is not known other than that there is at least one seam more than 4 feet thick. The number of beds present at Cokedale and Hamilton is not known, and very little is known about the McMurray coal.

Reserves are estimated at over 150 million tons.

MINERAL PROPERTIES IN SKAGIT-SAMISH BASINS*

Explanation for Figure 7-9

Metallic Minerals
(with production or reserves data where available)

Gold (91 properties)
17 - Allen Basin
13 - Anacortes
22 - Anoka
24 - Azurite (prod.–$972,000; reserves 14,500 tons)
33 - Blue Bird
16 - Chancellor (prod.–120 tons)
15 - Farrer Placer
13A - Fourth of July
36 - Glory of the Mountain
18A - Goat
40 - Justice
21 - Lazy Tar Heel Placer
19 - Mammoth (prod.–30,000 tons)
42 - Monte Cristo (prod.–$1.7 million)
18 - New Light (prod.–$400,000)
22 - North American
20 - Old Discovery Placer
41 - Peabody
38 - Rainy (prod.–20,000 tons)
14 - Seattle-St. Louis
20A - Tacoma
23 - Whistler

Iron (6 properties)
31 - Hamilton (prod.–5,000 tons; reserves 500,000 tons)

Chromium (8 properties)
29 - Cypress (prod.–70-80 tons)
30 - Last Chance
28 - Ready Cash (prod.–75 tons)

Copper (27 properties)
37 - Foggy
34A - Glacier Peak (reserves 30 million tons)
35 - Helena (prod.–150 tons)
39 - O and B (prod.–12 carloads)
34 - Sam Strom
32 - Stephens (prod.–45 tons)

Lead (23 properties)
26 - Boston (prod.–2 tons)
27 - Johnsburg (prod.–19 tons)

Manganese (1 property)

Molybdenum (1 property)
12B - Silver Creek

Nickel (16 properties)
31A - Mount Vernon (reserves–50 million tons)

Silver (14 properties)
25 - Willis and Everett

Zinc (1 property)

Nonmetallic Minerals
(with reserves data where available)

Asbestos (6 properties)
26 - Burlington
27 - Lyman

Coal (reserves–510.27 million tons)

Common clay (5 properties)
12 - Alger
25 - Bay View
22 - Concrete
21 - Friday Creek
29 - Tiloh

Diatomite (1 property)

Mineral water (3 properties)

Olivine (reserves–10 million tons)
20 - Scheel Clausen

Pumice (2 properties)
31 - Darrington
13 - Skagit River

Silica (8 properties)
16 - Bacon Creek
16 - Pressentin
16 - Scheel
17 - Silica Camp
15 - Stoner

Strontium (1 property)
30 - Alverson

Talc (12 properties)
18 - Alvard
28 - Clear Lake
18A - Dad's Girl
23 - Londonderry
18 - McMyrl-Wilson
18 - Rainbow
24 - Sadie Cudworth
14 - Skagit Talc Products

Stone Deposits

Limestone

Reserves
Less than 10,000 tons (7 properties)
10,000 to 1 million tons (11 properties)
1 million to 10 million tons (3 properties)
More than 10 million tons (4 properties)

Basalt (3 properties)

Other stone (3 properties)

*Some properties not plotted on map because of poor description of location and/or lack of space.

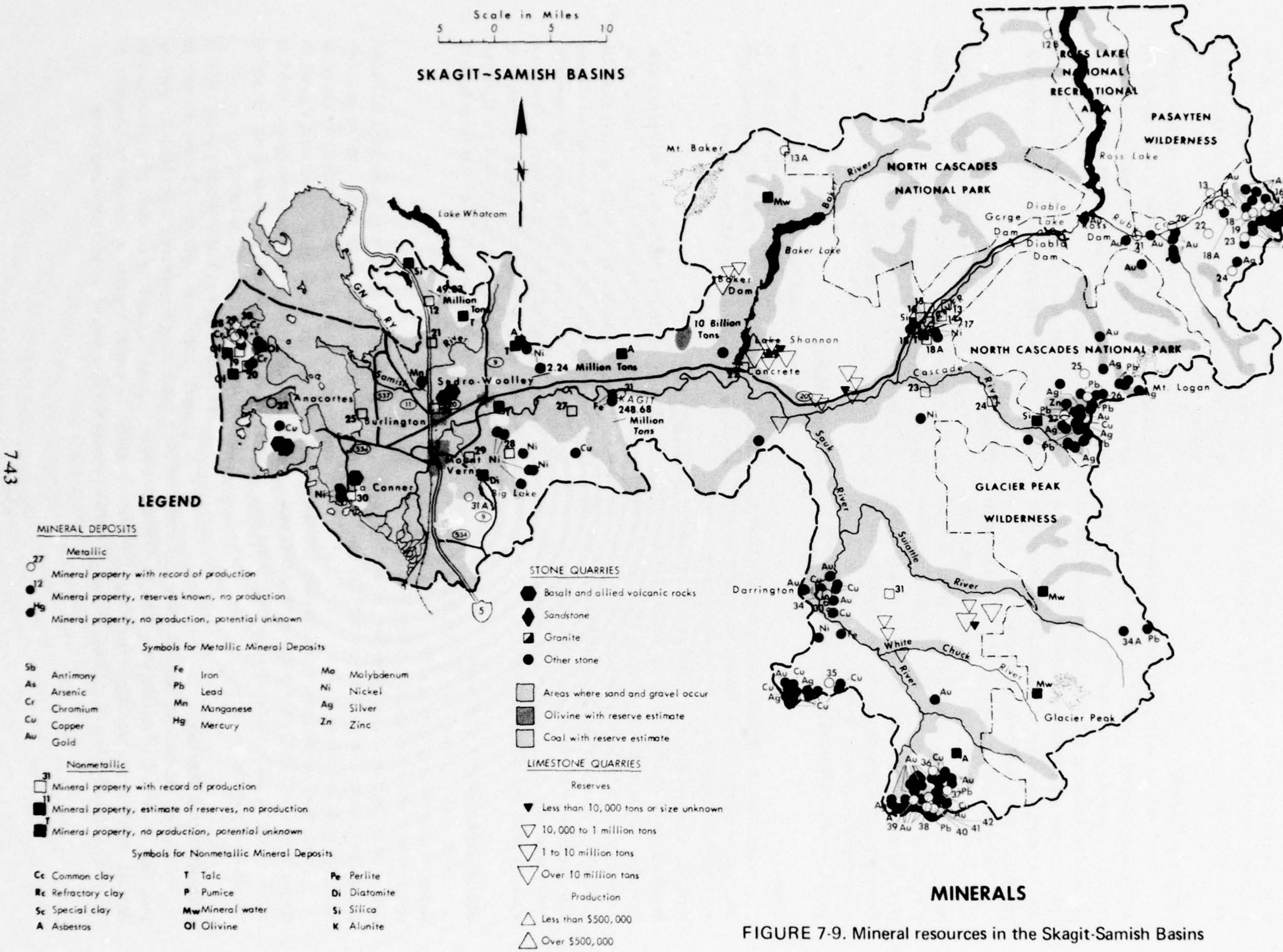


FIGURE 7-9. Mineral resources in the Skagit-Samish Basins

Blue Canyon reserves are about 50 million tons, Cokedale has about 212 million, and Hamilton has about 249 million.

Sand and Gravel

The best sand and gravel deposits are associated with glacial outwash material in the western part of the area, especially near Sedro Woolley. Most of the terrace deposits along the Skagit River are suitable for aggregate use also; however, many of the gravel bar deposits along the river are unsuitable because they contain too many soft rock fragments.

Well over 40 sand and gravel pits are known to have produced aggregate or fill material at one time or another. Practically all of them are in the western part of the drainage system, although there are a few pits along the upper reaches of the Skagit River. Complete production figures are not available, but it is estimated that over 8 million tons of sand and gravel has been produced between 1920 and 1965.

Clay

Clay deposits are fairly common in the western part of the Skagit-Samish Basins, but at the present time (1966), there is no clay production from the area. There are six pits (Fig. 7-9) that have a record of production—all of them either in glacial or lacustrine deposits. Some shale deposits in the Chuckanut Formation near McMurray are suitable for making red-burning ware, but they have not been utilized. All clay produced has been used in the manufacture of heavy ware and as an ingredient in making cement to raise the silica and alumina content.

Stone Other Than Limestone

Nine stone quarries are in the Skagit-Samish Basins: one in silica-carbonate rock, one in travertine, one in schist, and six in andesite. The schist is used as ashlar and flagstone; the travertine is used as a decorative stone; the others are used as rubble, landscape rock, and riprap.

Production records are not complete for the Basins; prior to 1913, no reports were made, and many of the totals subsequent to that time are not available for publication.

Asbestiform Materials

Of seven asbestiform mineral properties, only two have a record of production. The Burlington deposit, which is in a greenstone that crops out on a hill just north of Burlington, was used to make special cements. The fibrous material is a mixture of actinolite and fibrous soapstone. The Lyman deposit, which is near Hamilton, is reported to have shipped a small amount of amphibole asbestos.

Three of the asbestos properties contain serpentine asbestos (chrysotile), and four contain amphibole asbestos. As noted above, the production has been from the latter. All of the deposits are associated with basic and ultrabasic rocks.

Total production of asbestos is estimated at less than 1,500 tons. No estimate of reserves is available.

Diatomite

Only one diatomite deposit has been reported, and it has not had production. It is a 6- to 12-foot bed that covers about 15 to 20 acres and is overlain by from 6 to 12 inches of overburden. Reserves are estimated at about 10,000 tons.

Mineral Water

Of three mineral hot springs, none have been developed. They are the Baker Hot Springs in Whatcom County, and the Sulfur Hot Springs and Kennedy Hot Springs in Snohomish County.

Oil and Gas

The Chuckanut Formation of Paleocene age, cropping out in the western parts of the Skagit-Samish Basins, contains many beds that have physical conditions favorable for the accumulation of oil and gas. To the present time (1966), there has been only one test well drilled below 1,000 feet. A few deep water wells have encountered small gas pockets that bled off very quickly. Three water wells are reported to have had oil shows at ± 100 feet, but these reports are probably erroneous.

Peat

Fifteen major peat areas comprising 1,147 acres have been investigated. Of these peat areas, five contain more than 2 feet of sphagnum moss in some part of the bogs. Other peat deposits are known to exist, but as yet have not been investigated. All but three of the bogs studied are located on the glacial plain of the western part of the basin.

There is only one bog producing peat, and it is a comparatively new operation, having started in 1962. Production figures are not available for publication, and no quantitative estimate of reserves can be made; however, reserves are probably adequate to meet the demands of the area for many years.

Silica

Eight known silica deposits are in the form of massive quartz. Four properties in the area have a record of production. The material produced has been used as pulp stone, molding sand, and glass sand. No production figures are available for publication. Reserves are estimated to be well over 1 million tons.

Strontium

Only one strontium property is known. It is located about 1.5 miles southwest of La Conner (Fig. 7-9). The strontium minerals are scattered through a 3- to 4-foot-wide fracture zone in a serpentinized dunite. The richest solid ore zone is about 30 inches wide.

Information available on the property indicates that there are only a few thousand tons of ore available. Production from the property was primarily during World War I, when a few hundred tons of material was shipped. Since then, only a few small shipments have been made.

Pumicite

There are two occurrences of pumicite. The Skagit (Fig. 7-9, No. 13) consists of three deposits within a 40-acre area that at one time apparently was a lake basin. All three deposits are fine-grained light gray pumicite so uniform in texture that stratification is barely visible. The deposits contain high quality pumicite, but they are not very large. Reserves covered by less than 15 feet of overburden are estimated at 15,000 to 18,000 tons. A few carloads have been mined and shipped, but no figures are available for publication.

The Darrington deposit (Fig. 7-9, No. 31) is alluvial in origin and has had minor production.

Talc

Twelve talc properties are known; eight have a record of production. These Basins are unique in that they have within their bounds the only producing talc properties in Washington State. Production first started in 1929 or very shortly, thereafter, and has been continuous ever since. Three companies are currently (1966) engaged in the production of talc. The producing mines are the Rainbow, Skagit Talc Products, and the Clear Lake.

It is estimated that about 75,000 tons of talc worth about $800,000 has been produced. An estimate of reserves cannot be given because of lack of information.

Gold

The Azurite mine (Fig. 7-9, No. 24) has been one of the important gold-producing properties. Ore minerals are chalcopyrite, sphalerite, pyrite, pyrrhotite, and galena in a quartz vein. The vein cuts argillitic country rock and is from 2 to 4 feet wide. The material mined averaged 0.385 ounce of gold and 0.036 ounce of silver per ton, and production amounted to $972,000 during the 4 years from 1936 through 1939 that the property was active. Known high-grade material has apparently been depleted, but there is reported to be a proven reserve of 14,500 tons of ore averaging $11 per ton.

The Anacortes mine (Fig 7-9, No. 13) operated in the late 1930's and early 1940's; several thousand dollars worth of $18- to $20-per-ton ore was produced during that time. The gold was in a quartz vein that averaged 2 feet in width in slate, conglomerate, and diorite. The ore minerals are tellurides, sulfides, and free gold.

The Chancellor mine (Fig. 7-9, No. 16) operated between 1935 and 1939. Total shipments were 120 tons of ore that averaged 0.735 ounce of gold and 3.48 ounces of silver per ton. The mineralization is along shear zones in quartzite and consists of pyrite, arsenopyrite, galena, and sphalerite in a quartz-calcite gangue. The veinlets that fill the fractures along the overall shear zone are from 3 to 12 inches wide.

The Mammoth mine (Fig. 7-9, No. 19) reportedly produced 15,000 tons of ore prior to 1900, and 30,000 by 1942. Total production is reported to have been more than $1 million. Ore occurs in a 1- to 3-foot quartz vein that carries free gold, tellurides, pyrite, arsenopyrite, galena, and sphalerite. The vein cuts argillite and quartzite country rock.

The New Light mine (Fig. 7-9, No. 18) produced 60,000 tons of ore in the early part of the 20th century and several tons of high-grade ore from 1940 to 1942. Total value of production is estimated to have been about $400,000. The ore deposit is in a fracture zone in limy and graphitic argillite and consists of graphitic shear zones, interlacing quartz veinlets, and breccia zones cemented by quartz and sulfides. Ore minerals are free gold and gold-bearing pyrite.

The Monte Cristo mine (Fig. 7-9, No. 42) is one of the more famous mines of the Cascade Mountains. It was first opened about 1893, but after a few years of production was forced to close because of management and transportation problems. The mine pro-

duced 300,000 tons of ore having an estimated total worth of more than $1.7 million. The mineralization is in a shear zone that contains sulfide lenses 1 to 15 feet thick and up to 300 feet in diameter. Ore minerals include arsenopyrite, pyrite, sphalerite, galena, chalcopyrite, and jamesonite. The country rock is schist and quartz diorite.

The Rainy mine (Fig. 7-9, No. 38), which is near the Monte Cristo, produced 20,000 tons of ore that averaged nearly 0.6 ounce of gold and 2.2 ounces of silver per ton. The ore body is localized along a fracture zone in schist and andesite. Gold and silver values occur in arsenopyrite and pyrite.

There are 15 properties (Fig. 7-9, Nos. 13, 13A, 15, 17, 17A, 18A, 20, 21, 22, 23, 33, 36, 40, and 41) that have made test shipments of gold ore or have produced but for which no production records are available. In addition, there are at least 69 prospects that have gold as their principal value.

Copper

Shipments of copper are reported to have been made from five properties. None of the properties, however, has been able to maintain a sustained production. There are at least 27 copper properties in the area.

Twelve carloads of hand-sorted ore was shipped from the 0 and B mine (Fig. 7-9, No. 39) to the Everett smelter prior to 1901. Assays on the material shipped averaged $35 per ton. The mineralization occurs along fracture zones in andesite which are as much as 4 feet wide and vary from 2 to 50 feet in length.

Shipments from the Helena mine (Fig. 7-9, No. 35) amounted to 150 tons of ore that ran $19 to $32 per ton. The ore is said to be in at least two sulfide-bearing quartz veins in shear zones of granite.

One shipment reported to have been made from the Stephens property (Fig. 7-9, No. 32) assayed 2 percent copper. The property is within the Anacortes city limits, and is a 10-foot shear zone in granodiorite that is exposed for 600 feet. The zone is serpentinized and poorly mineralized.

The Foggy mine (Fig. 7-9, No. 37) is reported to have had production, but the amount is unknown. The mine is in a partially mineralized fracture zone that can be traced for 5,000 feet on the surface.

Some hand-sorted ore was produced from the Sam Strom property (Fig. 7-9, No. 34), but the amount is unknown. The ore body is a mineralized shear zone in diorite and slate. The zone is 500 feet wide and is shot with quartz veinlets.

The Glacier Peak property (Fig. 7-9, No. 34A) is probably the most important copper property. There has been no production from the property, but considerable exploration work has been done to interpret the ore zones. Mineralization is along closely spaced joints in quartz diorite. The ore minerals also replace ferromagnesian minerals in the rocks. Copper is distributed uniformly, and molybdenum erratically, throughout the deposit. The property consists of at least two ore bodies. The largest is reported to contain an estimated 20 million tons of ore that runs better than 0.40 percent copper with values in molybdenum, gold, and silver. The smaller ore body is reported to contain an estimated 10 million tons of ore that runs better than 0.40 percent copper, approximately 0.70 percent molybdenum, and additional values of gold, silver, and tungsten.

Chromium

Eight chromium properties are known, three of which have made small ore shipments. The Ready Cash mine (Fig. 7-9, No. 28) shipped chromite in 1917 and 1918. Total reported production was 75 tons. Chromite occurs as irregular veinlets an inch thick or more and clots a foot or more in diameter in a serpentine country rock.

The Last Chance property (Fig. 7-9, No. 30) is reported to have produced, but no records are available. Mineralization consists of thickly disseminated chromite grains in serpentine.

The Cypress mine (Fig. 7-9, No. 29) produced for a short time between 1956 and 1959 from the dunite and serpentine body on Cypress Island. Exact production figures are not available, but it is estimated that about 70 to 80 tons of ore was extracted and shipped.

Five other properties have undergone development work in the area, but none has made ore shipments.

Iron

Shipments have been made from only one of the six known iron deposits. This, the Hamilton (Fig. 7-9, No. 31), has produced about 5,000 tons. The ore body consists of discontinuous beds and lenses of magnetite and hematite in a fine-grained schist.

Reserves are estimated at 500,000 tons of ore that contains about 38 percent iron.

Lead

Twenty-three properties have lead as their principal value. Two of the properties, the Boston

(Fig. 7-9, No. 26) and Johnsburg (Fig. 7-9, No. 27), have made test shipments of 2 tons and 19 tons, respectively. Values on both properties are in veins containing lead, silver, zinc, gold, and copper. The vein at the Boston property is in foliated diorite, and the Johnsburg vein is along a shear zone in a schist.

No estimate of lead reserves is available.

Silver

There are at least 14 silver properties, one of which has had a record of production. The Willis and Everett mine (Fig. 7-9, No. 25) had a short period of activity early in the century, but the amount of production is not known. Assays of the high-grade ore ran $200 silver and $9 gold. The deposit consists of three veins that cut a granitic country rock and vary from 4 to 12 feet in width.

Nickel

At least 16 nickel properties are known. Practically all of the deposits are of the "nickel ledge" or silica-carbonate rock type. None of the properties has had commercial production, but one—the Mount Vernon (Fig. 7-9, No. 31A)—has made several test shipments.

An estimated 50 million tons of silica-carbonate rock is at the Mount Vernon property. Some 15 million tons of this has been blocked out by drilling. A sulfide breccia zone, discovered during the drilling, was estimated to contain between 15,000 and 50,000 tons of ore containing 0.2 percent nickel and 0.02 ounce of gold per ton. The approximate average tenor of millions of tons of the silica-carbonate rock is 0.2 to 0.3 percent nickel and about 0.02 ounce of gold per ton, but no effective method to concentrate the valuable minerals in this rock is presently known.

A second ore body that has received considerable attention is the Jumbo Mountain deposit. No estimate of reserves is available, but some assays showing as high as 13 percent nickel have been reported. The nickel minerals occur in dunite dikes and in concentrations of pyrrhotite along the contacts of the dikes with the schistose country rocks.

Zinc

The one zinc property is a small vein deposit and apparently has had very little work done on it.

Manganese

There is only one manganese property, and it has no record of production. The deposit consists of a concentration of pyrolusite in sand and gravel.

Molybdenum

One molybdenum property—the Silver Creek (Fig. 7-9, No. 12B)—is in a bleached silicified volcanic rock near the contact of a granodiorite intrusive. Molybdenite and chalcopyrite grains are scattered throughout the host rock, which is cut by small quartz stringers. Chip samples assayed 0.40 ounce of silver, 1.50 percent copper, and 0.15 percent molybdenum.

INTENSIVE LAND USE

Intensive land uses are predominantly in the western third of the Basins, but of the 1,947,963 acres in the Basins, less than 19,000 are utilized intensively at the present time.

There are eight (8) incorporated municipalities, and approximately nineteen unincorporated places. Total population of the incorporated municipalities is 26,097, approximately 40 percent of the Basins' population.

INCORPORATED CITIES AND TOWNS

Anacortes

The city of Anacortes is the largest of the incorporated towns in the Skagit-Samish Basins. Located on Fidalgo Island in Skagit County, Anacortes is the port of entry on the Strait of Georgia and the ferry terminal of the San Juan Island route to Vancouver Island, British Columbia. The city was originally settled in 1860, platted in 1876, and incorporated in 1891.

Population of the city in 1940 was 5,875, and in the following ten years increased about 1,000. By 1960, the population was 8,414, and in 1967, 8,750. The projection for 1970 is 10,000. The population growth factors are essentially expansion of existing industry, new industry, and increased recreational activity. Pleasure boating on Puget Sound, as well as ready access to duck, bird, and big game hunting is easily available. Canned and frozen fish, paper pulp, plywood, oil refinery products, adhesives, shingles, nonorganic and organic chemicals, poles and pilings,

and lumber and logs are principal products of the area.

Mount Vernon

The city of Mount Vernon, county seat of Skagit County, is situated on the Skagit River several miles from Skagit Bay on Puget Sound. Three years following the first settler's arrival in 1860, a small settlement had developed; in 1884, Mount Vernon was named county seat and in 1890, incorporated. Land was cleared and agriculture, dairying, and the processing of their products replaced lumber and logging as the leading industries. The fertile Skagit Valley is the richest farming county in the State, and Mount Vernon is the retail trade center for the valley.

The population of the city has increased from the 5,230 of 1950 to a 1967 population of 8,402, a 66 percent increase.

Sedro Woolley

The city of Sedro Woolley is located in Skagit County northeast of Mount Vernon, and had a 1967 population of 3,850. The townsite of Sedro was platted in 1889 and the town incorporated in 1891 while the town of Woolley was platted in 1890 and incorporated in 1891. In 1898, the two united.

Sedro Woolley is a trade and food processing center within the Skagit Valley. Located near, or within the city are several wood products industries, hardwood mill, and the Northern State Hospital for the mentally ill, which employes several hundred people. One of the major manufacturing firms of the area is the Skagit Steel and Iron Works, the world's largest manufacturer of logging loader and yarding equipment. The city's population increase between 1950 and 1960 was 12.3 percent from 3,705 to 3,850.

Burlington

The city of Burlington, with a 1967 population of 3,081, increased 26.3 percent between 1950 and 1960, or from 2,350 to 2,968. Located in Skagit County, just north of Mount Vernon, Burlington was settled in 1882, incorporated in 1902 and remains one of the trading centers of the Skagit Valley.

La Conner

The city of La Conner, incorporated in 1883, was the first incorporated town in Skagit County, but incorporation was repealed in 1886, and reinstated in 1890. Located a few miles southeast of Anacortes on the Swinomish Slough, La Conner had a 1967 population of 675, an increase of 81 since 1950.

Other incorporated cities in the Skagit-Samish Basins are Concrete, incorporated in 1909 with a 1967 population of 700; Lyman, incorporated in 1909 with a 1967 population of 430; Hamilton, incorporated in 1891 with a 1967 population of 209.

Unincorporated townships in the Skagit-Samish Basins include Edison, Samish, Guemes, Clear Lake, Big Lake, Conway, McMurray, Oso, Hazel, Fortson, Monte Cristo, Silverton, Newhalem, Marblemount, Rockport, Sauk, Van Horn, and Mansford.

TRANSPORTATION

Rail—The area is served by the coastal routes of the Great Northen, Northern Pacific, and Milwaukee Railroads.

Highways—Interstate Highway 5 crosses the basins from south to north. The main developed road up the Skagit Valley is State Highway 20.

Navigation—The Skagit River formerly was considered navigable to Marblemount, 78 miles above the mouth. River navigation has diminished with development of land transportation and presently, aside from towing of logs and certain recreational uses, navigation stops at Mount Vernon.

Airways—There are numerous small airfields to serve the basin.

LAND USE CHARACTERISTICS

There are 1,947,963 acres of land within the Skagit-Samish Basins, and 35,409 acres of inland water. Table 7-7 contains the figures showing the acreages of the major land uses within the Basins.

Figure 7-6 portrays the arrangement of the present land use for the Skagit-Samish Basins. From the map-Figure 7-5, it can easily be seen that the major portion of land in the Skagit-Samish Basins supports a forest cover.

Intensive Land Use

Intensive land use at the present time (1967) occupies some 18,804 acres or 1.0 percent of the Basins' land area. Most of the population is within the Basins' incorporated or unincorporated places, although a few intensive uses are scattered throughout the Basins. The following list indicates the land use figures for the intensive land use subgroups.

Railroads	Roadways	Airports	Urban (Built-up)	Total
775	8,274	597	9,158	18,804

Rural Nonagricultural

Part of the land uses classified within the Rural Nonagriculture category are similar in character and often are the forerunner of lands which will be intensively used in the future. The following list shows the subgroups and acreages in the Rural Nonagricultural land use category.

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm yards)	Total
8,201	0	6,534	5,357	20,092

The acreage devoted to mining activity here is the largest of any of the River Basins, and is indicative of its importance in the Basins. The actual use of the land in mining operations does not necessitate the inclusion of structures on the land, but there is little question in most instances of the intense use to which the land is being put.

Land Ownership

Of the total land area (1,913,000 acres) in the Skagit-Samish Basins, 12.9 percent is in private ownership, 9.9 percent in private corporate ownership, 71.8 percent in Federal ownership, 4.6 percent in State ownership, and .8 percent in local government ownership. The bulk of the private, private corporate, Federal, and State ownerships are forested areas. Land areas owned by local government (city, county and special districts) are largely located in the western third of the Basins. These land areas are mainly related to intensive use, consisting of streets, facilities, local parks and similar areas. Other (non-forest) private ownerships are also located primarily in the western third of the Basins and consist mainly of intensive, rural nonagricultural and agricultural land areas.

TRENDS AND POTENTIALS

Intensive land use in the Skagit-Samish Basins amounts to some 19,000 acres, somewhat less than a full township (23,040 acres) of present occupancy. This intensively used land area amounts to less than 1 percent of the total Basins' area. Requirements for intensive land use in the Basins are presently being filled in and around existing communties, mainly Anacortes, Mount Vernon, and Sedro Woolley. Within the Skagit-Samish Basins there are approximately six (6) townships comprising some 138,000 acres which are located mainly in a north-south corridor along either side of Interstate 5, the Skagit River Valley east of Mount Vernon and an area around Anacortes. It should be noted that the Basins contain, in their western third, a large amount of prime agricultural land. Conversion of these lands in significant amounts should be considered undesirable, thus limiting the potential for intensive development. Furthermore, much of the Skagit River Valley is a historic flood plain with major and frequent flooding problems. This factor should also restrict intensive development possibilities to specifically suitable locations outside the flood plain.

PRESENT AND FUTURE NEEDS

The Skagit-Samish Basins have been one of the prime agriculture basins within the Puget Sound Area, with over 100,000 acres of land devoted to this use. With a major portion of the agriculture land in the flood plain, every effort should be made to assure that the intensive land uses are restricted from these areas.

Population is projected to increase from 53,000 in 1963 to 118,200 by the year 2020. This means there will be a need for a total of 23,600 acres of land for intensive uses, an increase of approximately 4,600 acres over the next fifty years. A large percentage of the increase in intensive land uses should be guided to develop in and around the city of Anacortes. Industrial land will be needed to accommodate expanding and new wood processing facilities, paper and pulp industries, oil refining, plus assorted other industrial uses. Provision for additional industrial lands on the waterfront should be made to provide for an expanding port. Intensive land uses will develop at various locations along Interstate 5. Some of this development will be in the flood plain and provision must be made to give this new development proper flood plain protection. The cities and towns that are located in the Skagit River Flood Plain should be restricted from further growth, unless ample flood plain protection is provided, which would mean at least fifty years protection and, hopefully, one hundred years

protection. Figure 7-10 portrays the generalized future land use pattern (C_2) for the year 2020.

Previous projection of lands available and suited for intensive land use included 138,000 acres in the Skagit-Samish Basins. Projected land use trends show that there will be a need for only 23,600 acres of land for intensive land use purposes by 2020. Thus, we have over 100,000 acres of land in the Basins that is suited for development into intensive use, but which will not be developed. This will provide the necessary tool to allow careful selection of areas to be developed intensively, plus the necessary provisions to suggest a high degree of maintenance of the agricultural lands in the Basins.

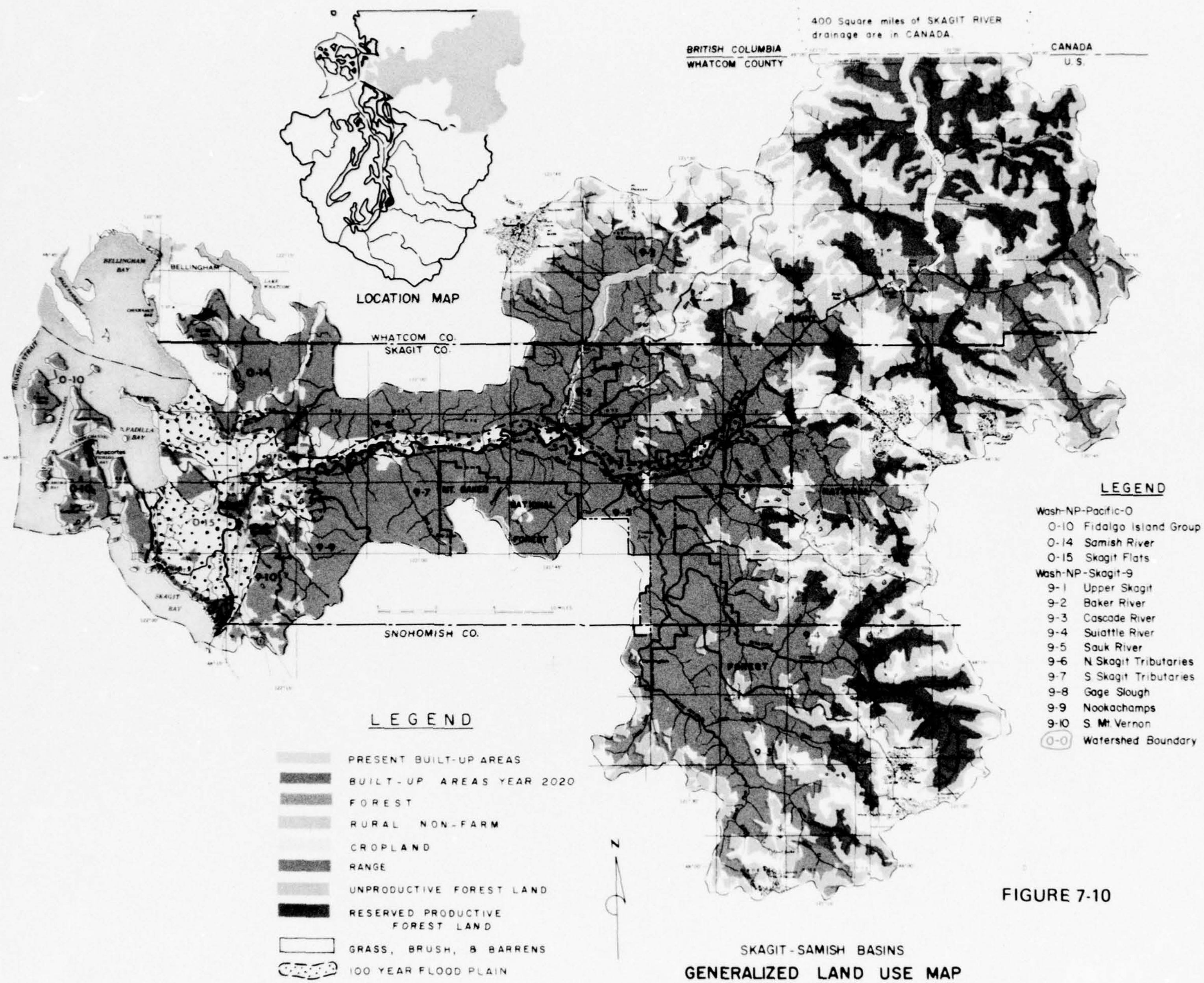
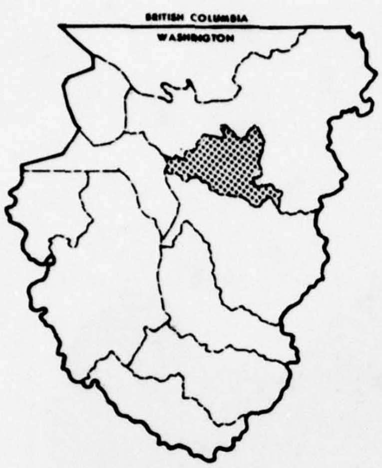


FIGURE 7-10

SKAGIT-SAMISH BASINS
GENERALIZED LAND USE MAP
Alternative C2 –2020

STILLAGUAMISH BASIN



The Stillaguamish Basin, located in the north sector of the Puget Sound Area, lies between the Skagit-Samish Basins on the north and the Snohomish Basin on the south. The area includes portions of Skagit and Snohomish Counties, and contains a hydrologic area of some 438,348 acres. The source of the Stillaguamish is in the vicinity of Vesper Peak which is about 20 miles west of the summit of the Cascade Mountains. This geological position places Stillaguamish outside the influence of the high Cascades. Major tributaries include the North and South Forks of the Stillaguamish River, Boulder Creek, and Pilchuck Creek.

Population

The population of the basin in 1967 was 18,300 persons. Projections show that the population will grow to 30,200 by 1980, 48,500 by 2000 and 77,800 persons by the year 2020. This growth will take place adjacent to the existing areas of development in the western portion of the basin.

Land Use

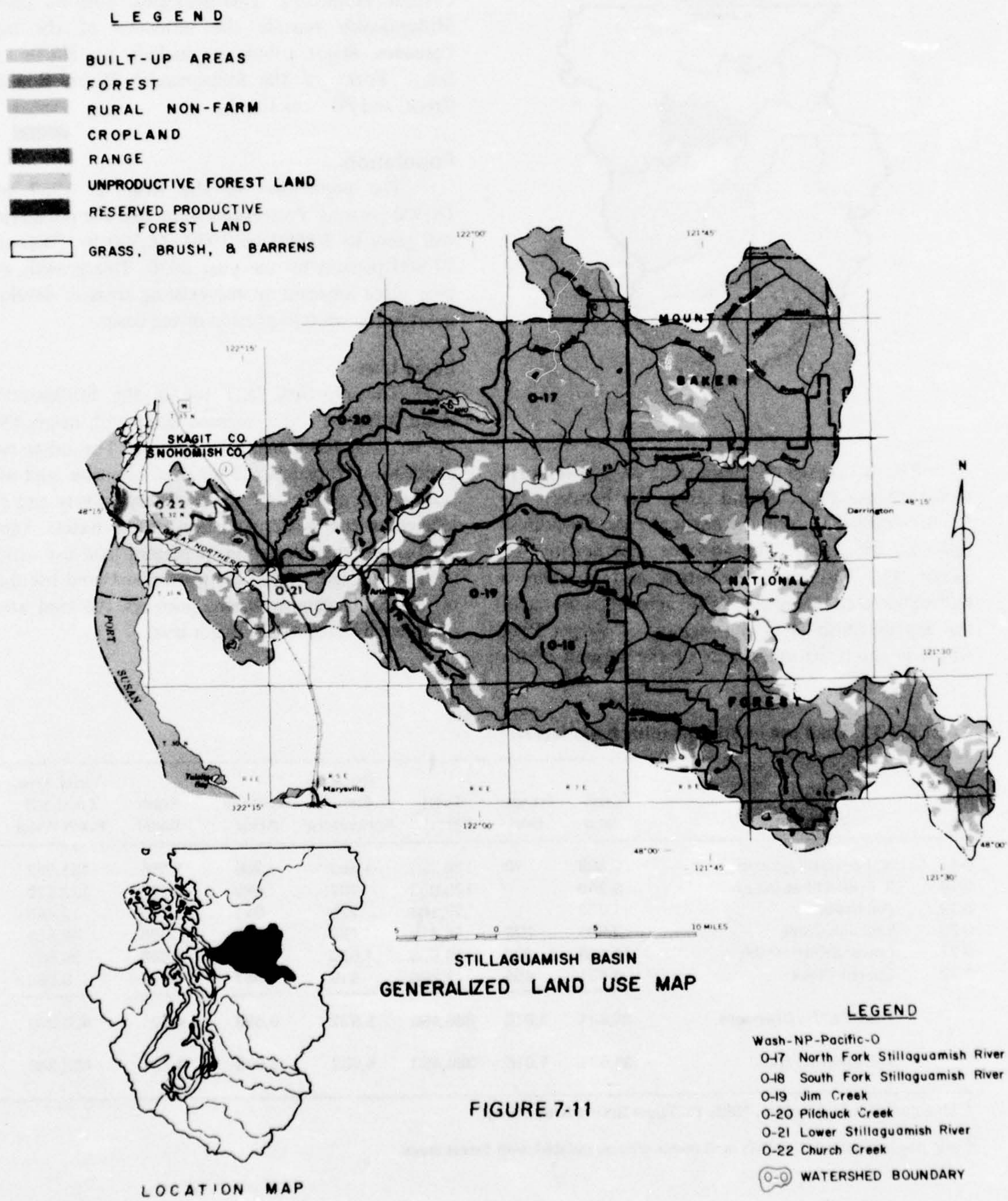
The principal land use in the Stillaguamish Basin is forests and associated lands with nearly 89% of the total Basin being in this use. The other two major uses, croplands and urban or intensive land uses occupy 8% and 1% of the land respectively and are located in the western portion of the Basins. Table 7-13 shows the tabulation of present land use within the Basin. Figure 7-11, the generalized land use map of the Stillaguamish Basin, portrays the land areas occupied by each of the major uses.

TABLE 7-13. Land use in Stillaguamish Basin (acres)[1]

Map No.	Watershed	Crop-land	Range-land	Total Forest[2]	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
0-17	N. Fork Stillaguamish	7,388	10	170,296	1,592	1,308	1,365	181,959
0-18	S. Fork Stillaguamish	3,240		123,933	787	883	777	129,620
0-19	Jim Creek	1,233		27,103	730	241	146	29,453
0-20	Pilchuck Creek	2,803	227	44,316	793	670	856	49,665
0-21	Lower Stillaguamish	15,436	323	18,096	1,520	2,639	1,568	39,582
0-22	Church Creek	4,431	456	1,706	510	957	9	8,069
	Total Pacific Drainages	34,531	1,016	385,450	5,932	6,698	4,721	438,348
	Stillaguamish Basin	34,531	1,016	385,450	5,932	6,698	4,721	438,348

[1] Unadjusted measuremens, 1966, for Puget Sound Area Study.

[2] *Figures include nonforested land commonly associated with forest areas.*



STILLAGUAMISH BASIN
GENERALIZED LAND USE MAP

FIGURE 7-11

AGRICULTURE

PRESENT STATUS AND POTENTIAL

The Stillaguamish Basin is confined to southwestern Skagit County and northwest Snohomish County. Approximately one-third of the Basin lies in Skagit County and the remaining two-thirds in Snohomish County.

The western part of the Basin has extensive alluvial flats and glacial terraces, graduating into rugged mountainous areas in the east. Of the total land area of 433,627 acres, those lands outside the national forest boundaries have been mapped by a medium-intensity soil survey. Lands within the national forest have been mapped by a low-intensity soil survey suitable for reconnaissance use. Of the 258,325 acres of land mapped with the medium-intensity soil survey, nearly 125,000 acres are classified in Land Use Capability Classes II through VI.

These 125,000 acres of land have the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, and IV are suited for either cropland or urban uses, and Class VI has potential for urban developments.

The Stillaguamish River drains an area of 684 square miles. Its principal tributaries are the North Fork Stillaguamish River and the South Fork Stillaguamish River.

The Stillaguamish Basin provides one of the smaller valley systems in the Puget Sound Area. The system includes many flood and drainage problem areas which require corrective measures before their potential can be attained. The lower flood plain contains about 26,000 acres of level or gently undulating river bottom lands and tidelands. The upper reaches of the Basin are steep, mountainous valleys with turbulent streams. Below Arlington, the valley drops almost to sea level and widens to a flat, fertile plain as much as two miles wide and thirteen miles long.

Production

Farming and forestry are the main users of land in the Basin. Although considerable quantities of vegetables and berries are produced, approximately three-fourths of the cropland is used to support the livestock industry. Total value of farm production is over $6 million annually.

Forestry continues as a major industry of the Stillaguamish Basin, and supports numerous mills, including several lumber mills, a plywood mill, a cedar shake mill, and a plant which manufactures hardwood paper roll forms.

Flooding

Climatic conditions induce one flood-producing season annually. It usually occurs in the late fall or in winter as the result of excessive precipitation.

Discharges in excess of channel capacity cause water to spread across the valley, where it remains until the river drops. In many areas, water is trapped by topographic detail until it can seep into the soil. Excessive rainfall causes similar flooding conditions as well as swamping of the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV, Watershed Management. The principles and conditions discussed therein apply to the Stillaguamish Basin and need not be repeated here.

Watersheds

Six watershed areas requiring solutions to problems of development to achieve potential productivity of the Basin are shown on Land Use Map (Figure 7-11) and on the Land Capability Map (Figure 7-12).

These watersheds are: North Fork Stillaguamish River (0-17), South Fork Stillaguamish River (0-18), Jim Creek (0-19), Pilchuck Creek (0-20), the Lower Stillaguamish River (0-21), and Church Creek (0-22). There is very little cultivated agricultural land along Pilchuck Creek, Jim Creek, or the South Fork Stillaguamish River, and only a small amount along the North Fork Stillaguamish River. The North and South Forks of the Stillaguamish River, Jim Creek, and Pilchuck Creek are mostly in forest, with much of the first two being national forest.

The Lower Stillaguamish River watershed and Church Creek watershed are the center of the Basin's fertile agricultural region. Almost 60 percent of the Basin's cropland and 55 percent of its urban development are concentrated in these two watersheds.

Many of the farmlands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions are summarized in the Puget Sound Area section

of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the Stillaguamish Basin is shown in Table 7-13. The following tables are to indicate the potential development possible within acceptable land use standards.

Table 7-14 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-15 shows the number of acres in each capability class, subclass, and unit, by watersheds, in the Stillaguamish Basin. This table can be used with the description of capability units to estimate the potential for development.

TABLE 7-14. Distribution and value of production by crops in Stillaguamish Basin

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	357	505	1.46	24,355	.65
Field crops	62	87	.25	25,985	.69
Vegetables	2,097	2,967	8.59	636,724	16.87
Berries	350	495	1.43	509,545	13.50
Nursery products	151	214	.62	373,276	9.89
Cropland not used	1,105	1,564	4.53	--	--
Sub-Total	4,122	5,832	16.88	1,569,885	41.60
Hay	4,950	7,002	20.28	328,189	8.70
Hay aftermath	--	--	--	209,635	5.56
Sub-Total	4,950	7,002	20.28	537,824	14.26
Silage (grass)	1,839	2,602	7.54	172,385	4.57
Grass aftermath	--	--	--	77,901	2.06
Sub-Total	1,839	2,602	7.54	250,286	6.63
Silage (corn) fodder	579	819	2.37	54,264	1.44
Pasture (cropland)	12,920	18,276	52.93	1,360,762	36.07
Sub-Total	20,288	28,699	83.12	2,203,136	58.40
Total	24,410	34,531	100.00	3,773,021	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.

LEGEND

LAND SUITED FOR CULTIVATION AND OTHER USES

I Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

IV Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

V Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

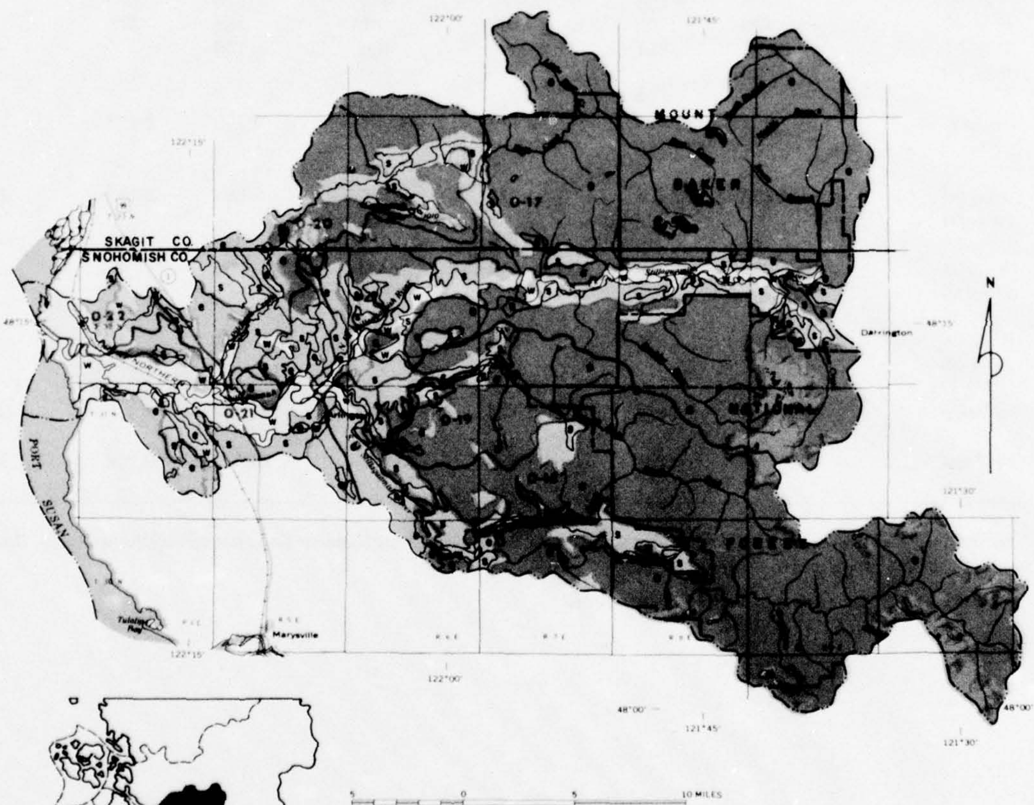
VI Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

VII Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

VIII Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.



LOCATION MAP

STILLAGUAMISH BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

FIGURE 7-12

LEGEND

Wash-NP-Pacific-O
0-17 North Fork Stillaguamish River
0-18 South Fork Stillaguamish River
0-19 Jim Creek
0-20 Pilchuck Creek
0-21 Lower Stillaguamish River
0-22 Church Creek
0-0 WATERSHED BOUNDARY

TABLE 7-15. Land Capability units in Stillaguamish Basin (acres)[1]

Capability units[2]	WATERSHEDS 0-17	0-18	0-19	0-20	0-21	0-22	Total
II ws 03	215	269	25	70	110		689
II ws 04	4,372	415	75	548	8,977	1,860	16,247
II ws 06	494	617	25	723	1,332	200	3,391
II Total	5,081	1,301	125	1,341	10,419	2,060	20,327
III ew 01	110	105	731	545	1,675	1,525	4,691
III es 02	30	35		2,525	50		2,640
III ws 01	2,236	776	390	190	1,554	90	5,236
III ws 02	60						60
III ws 08	405	195	64	20	295	45	1,024
III ws 09	435	269	185	445	920	130	2,384
III ws 10	125	63	65	65	135	372	825
III so 01	3,790	981	683	165	140		5,759
III sw 09	70			130			200
III Total	7,261	2,424	2,118	4,085	4,769	2,162	22,819
IV ew 14				195			195
IV ew 22	1,352	3,490	315	5,100	9,083	2,302	21,642
IV es 09				300			300
IV ws 05	95	15	5		384	20	519
IV ws 06	327	564	119	540	335	15	1,900
IV ws 10				140			140
IV ws 11				35			35
IV so 01	2,006	1,575	995	450	520	10	5,556
IV se 05	125						125
IV Total	3,905	5,644	1,434	6,760	10,322	2,347	30,412
II-IV Total	16,2[illegible]7	9,369	3,677	12,186	25,510	6,569	73,558

1 Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include land within national forest boundaries.

2 See Exhibit 1 for description of capability units.

TABLE 7-15. Land capability units in Stillaguamish Basin (acres)[1] (cont.)

Capability Units[2]	WATERSHEDS 0-17	0-18	0-19	0-20	0-21	0-22	Total
VI ew 21	1,757	3,220	1,640	7,409	1,180	335	15,541
VI es 19	2,654	898	216	600	935	50	5,353
VI es 20				680			680
VI es 22				270			270
VI ws 19	280	20			10	5	315
VI so 12	120			730			850
VI so 13				130			130
VI so 18	7,828	6,775	1,850	1,691	5,422	135	23,700
VI se 13	185						185
VI se 17	1,175	275	400	899	1,327	130	4,206
VI Total	13,999	11,187	4,106	12,490	8,874	655	51,230
VII ew 30				1,175			1,175
VII es 29	210	20					230
VII es 35				595			595
VII es 36	55,911	25,696	18,692	22,414	2,494	265	125,472
VII so 23	1,357	1,222	220		539	77	3,406
VII Total	57,478	26,938	18,912	24,184	3,024	342	130,878
VIII ws 00	668	460	95	10	315		1,548
VIII ws 23	10				256	494	760
VIII ws 24	21	245	30	10	35		341
VIII so 00				10			10
VIII Total	699	705	125	30	606	494	2,659
V-VIII Total	72,176	38,830	23,143	36,623	12,504	1,491	184,767
II-VIII Total	88,423	48,199	26,820	48,809	38,014	8,060	258,325

[1] *Unadjusted measurements*, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include land within national forest boundaries.

[2] See Exhibit 1 for description of capability units.

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the Stillaguamish Basin will increase from 18,300 persons in 1967 to about 77,800 by 2020, based on Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 12,630 acres presently in intensive and rural nonagricultural use could provide ample acreage for new intensive development to the year 2000 without encroachment onto the croplands of the Basin. After the year 2000, approximately 337 acres must be added from some other land use in order to keep the density per acre at six.

Cropland Needs

The Stillaguamish Basin presently has 34,531 acres of cropland. The Basin is expected to lose some cropland to other uses but will gain acres diverted from forest, so that cropland will total about 35,000 acres by 2020. The percent increases needed, by crops, for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Data in Table 7-16 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Stillaguamish Basin is summarized under the topic "Program Implementation" immediately following "Forestry." A more complete description is found in Appendix XIV, Watershed Management.

TABLE 7-16. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	23,075	23,075	23,075
Watershed protection and rehabilitation[2]	acre	35,547	35,547	36,016
Drainage improvement	acre	13,541	22,568	30,091
Irrigation development[3]	acre	11,675	16,670	30,000
Water for irrigation[4]	ac.ft.	22,416	32,006	57,600

[1] A total of 34,780 acres in the Stillaguamish Basin are subject to flooding. Only the amount of cropland needing protect n through 2020 has been evaluated here.

[2] Includes 1,016 acres of rangeland.

[3] According to Appendix VII, Irrigation, there were 2,500 acres (using 4,800 acre-feet of water) irrigated in 1966. Irrigation Appendix projections show 6,500 acres irrigated by 1980, 10,500 acres by 2000, and 10,500 acres by 2020.

[4] Based on gross diversion requirements of 1.92 acre-feet per acre, estimated by Irrigation Committee in Appendix VII, Irrigation.

FORESTS

PRESENT STATUS

The Stillaguamish Basin is well covered with forests with some 384,000[1] acres classified as forest land (Table 7-17). Forests are located throughout the area and reach into the lower lands adjacent to farms and communities. Of the total forest land only a small amount, approximately 4,000 acres, is in a reserved status. The available forest land is classified by resource zones in the tabulation.

[1] Does not include nonforested lands commonly associated with forest areas.

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	95,810	25.7
Principal Forest	225,650	60.4
Upper Forest	43,990	11.8
Supalpine	7,500	2.1
Total availabie	372,950	100.0

The Stillaguamish Basin contains 354,000 acres of commercial forest land capable of producing crops

TABLE 7-17. Stillaguamish Basin—Area of forest land, in acres, by ownership and type.

Cover Type or Land Class	Available: National Forest	Available: Other Federal	Available: State & County	Available: Private	Available: Total Available	Unavailable	Total Available & Unavailable
Douglas-fir							
seedlings and saplings	470	100	2,900	1,780	5,250	30	5,280
poletimber	2,200	40	9,980	13,420	25,640	50	25,690
small young growth sawtimber	4,860	30	2,910	8,020	15,820	1,340	17,160
old growth and large young growth sawtimber	6,040	--	570	1,100	7,710	980	8,690
True-Fir—mountain hemlock							
seedlings and saplings	160	--	1,000	260	1,420	--	1,420
poletimber	--	--	270	110	380	--	380
small sawtimber	1,020	--	230	290	1,540	--	1,540
large sawtimber	35,250	--	1,610	3,790	40,650	100	40,750
Western hemlock							
seedlings and saplings	4,790	1,750	7,260	15,760	29,560	--	29,560
poletimber	780	80	10,620	13,930	25,410	--	25,410
small sawtimber	850	150	2,100	4,700	7,800	10	7,810
large sawtimber	66,480	590	4,110	18,150	89,330	760	90,090
Western redcedar							
seedlings and saplings	--	--	--	50	50	--	50
poletimber	--	--	--	90	90	--	90
small sawtimber	--	--	--	10	10	10	20
large sawtimber	13,820	--	760	1,200	15,780	90	15,870
SUBTOTAL, softwoods	136,720	2,740	44,320	82,660	266,440	3,370	269,810
Hardwoods							
seedlings and saplings	170	--	830	5,420	6,420	10	6,430
poletimber	1,590	390	16,840	33,310	52,130	50	52,180
small sawtimber	500	20	3,060	20,780	24,360	210	24,570
large sawtimber	--	--	--	110	110	--	110
SUBTOTAL, hardwoods	2,260	410	20,730	59,620	83,020	270	83,290
Nonstocked							
cutover	1,090	410	1,890	1,380	4,770	--	4,770
deforested by fire	--	--	--	--	--	--	--
SUBTOTAL, nonstocked	1,090	410	1,890	1,380	4,770	--	4,770
TOTAL, productive land	140,070	3,560	66,940	143,660	354,230	3,640	357,870
Subalpine	7,090	--	300	110	7,500	--	7,500
Noncommercial, rocky	10,270	70	390	490	11,220	290	11,510
TOTAL unproductive land	17,360	70	690	600	18,720	290	19,010
TOTAL, all forested land	157,430	3,630	67,630	144,260	372,950	3,930	376,880

of industrial wood. These lands support a sawtimber inventory under the International ¼-inch Rule of 9.8 billion board feet (Table 7-18). This represents 7.0% of Puget Sound Area's commercial forest land and 9.6% of its sawtimber volume. Private lands in the Basin make up 40% of the commercial forest lands. Large holdings, mostly corporate, account for 46,900 acres and medium sized ownerships 1,500 acres. The largest private classification of 96,000 acres is found in farm woodlots, small forested tracts and other miscellaneous ownerships. Public forest lands include 228,700 acres of commercial timber land. Ownership is 69% National Forest, 29% State and a small amount of miscellaneous public ownership of 2%.

The Stillaguamish Basin supports several forest products industries located in Arlington and Stanwood. The 10 manufacturing plants located in the Basin produce lumber, shakes and shingles, specialty products, chips, decking, and fencing. The estimated raw material needed is 210,000 board feet daily.

TABLE 7-18. Stillaguamish Basin—Volume of sawtimber and growing stock, by ownership on productive forest land.

	Available						
Species or Group	National Forest	Other Federal	State & County	Private	Total Available	Unavailable	Total Available & Unavailable
Sawtimber—Thousand board feet, International ¼-inch Rule							
Douglas-fir							
small sawtimber	74,550	570	58,740	131,250	265,110	15,300	280,410
large sawtimber	333,400	150	45,820	75,980	455,350	37,820	493,170
True-fir—mountain hemlock							
small sawtimber	17,660	--	4,320	5,030	27,010	--	27,010
large sawtimber	2,166,960	--	102,280	225,080	2,494,320	5,990	2,500,310
Western hemlock							
small sawtimber	15,860	2,700	43,520	93,880	155,960	180	156,140
large sawtimber	3,486,400	30,180	231,620	944,920	4,693,120	43,500	4,736,620
Western redcedar							
small sawtimber	--	--	--	310	310	220	530
large sawtimber	1,236,720	--	54,200	73,460	1,364,380	7,250	1,371,630
SUBTOTAL, softwoods	7,331,550	33,600	540,500	1,549,910	9,455,560	110,260	9,565,820
Hardwoods							
small sawtimber	6,750	460	48,370	235,540	291,120	2,310	293,430
large sawtimber	1,630	300	17,230	36,310	55,470	60	55,530
SUBTOTAL, hardwoods	8,380	760	65,600	271,850	346,590	2,370	348,960
TOTAL sawtimber, all species	7,339,930	34,360	606,100	1,821,760	9,802,150	112,630	9,914,780
Growing Stock—Million cubic feet							
Douglas-fir	74.3	0.1	19.0	37.7	131.1	9.7	140.8
True fir—mountain hemlock	395.2	--	19.3	41.6	456.1	1.1	457.2
Western hemlock	682.4	6.4	53.6	202.4	944.8	8.5	953.3
Other softwood species	489.6	--	21.5	29.2	540.3	3.0	543.3
SUBTOTAL, softwoods	1,641.5	6.5	113.4	310.9	2,072.3	22.3	2,094.6
hardwoods	3.3	0.3	25.9	107.4	136.9	0.9	137.8
TOTAL growing stock, all species	1,644.8	6.8	139.3	418.3	2,209.2	23.2	2,232.4

Forest land management in the Stillaguamish Basin does not have acute problems. The greatest need is an improved form of management that will bring better forestry and marketing skills to the great number of small ownerships. The land is at a lower elevation than most drainages in the Puget Sound Basin and is highly productive of timber crops. Forest products industries, due to the relatively high number of small businesses, have problems in marketing and transportation of finished materials to railhead.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

No determination of the demand for wood products is made specifically for the Stillaguamish Basin. The nature of the forest products industries, particularly the relative ease of log transportation between the basins, would make such a determination rather meaningless. In addition, a specific figure would imply that a production goal was established for the Basin, which is not the case. Production goals are established for the Puget Sound Area as a whole, with the assumption that considerable shifts in production between the basins will occur, depending upon the actual pattern of industrial and land use development.

For sake of Basin comparison, however, there is some value in showing the percentage of demand that may be supplied by the Stillaguamish Basin in the future. In 2020, the Stillaguamish Basin is expected to contain about 8% of the commercial forest land in the Puget Sound Area. The percentage in earlier periods is slightly lower. It is therefore assumed that the basin will supply approximately 8% of the total wood products demand in the future.

The effect of competing uses for forest lands is discussed in detail in the section covering the Puget Sound Area. The estimated diversion of forest land from these causes in the Stillaguamish Basin is shown below.

Type of Land Diversion	Acres Diverted (2020)
Parks, Wilderness, Campgrounds or Other Recreation Use	3,610
Roads and Highways	8,740
Urban-Industrial Development	1,080
Reservoirs, Powerlines, and other miscellaneous conversion	- - - -
Private Land Use Reservations	15,400
Total	28,830

The current and prospective changes in the commercial forest land base from all causes are given below.

Specific measures for soil and water protection are discussed in Appendix XIV, Watershed Management.

PROGRAM IMPLEMENTATION AGRICULTURE AND FORESTS

In order to adequately provide for the needs of the Stillaguamish Basin, as set forth in the previous pages, the following plan has been developed. It is multipurpose in nature and will provide for floodwater prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development. Other measures provided for include water

Current and projected commercial forest area in the Stillaguamish Basin 1965-2020 (in thousand acres)

	Ownership						
	Private			Public			
Period	Large	Medium	Small	NF	Other Federal	Other	Total
1965	46.8	1.5	95.4	140.1	3.5	66.9	354.2
1980	49.7	1.5	88.0	139.1	3.5	65.9	347.7
2000	55.7	1.5	74.1	137.9	3.5	64.9	337.6
2020	58.1	1.4	62.3	136.6	3.4	63.7	325.5

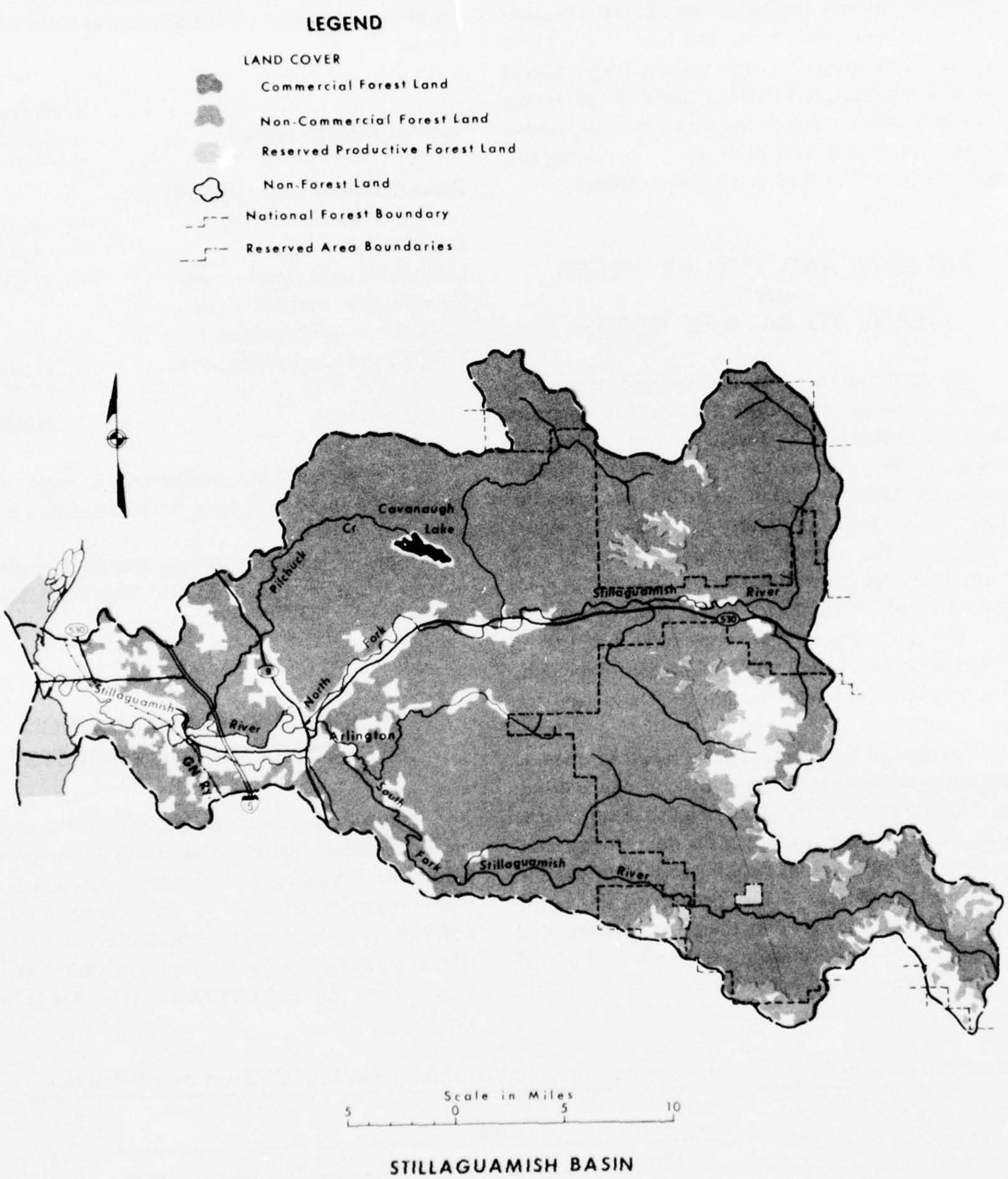


FIGURE 7-13. Forest lands in the Stillaguamish Basin

quality and quantity control, recreation, and fish and wildlife development.

This plan contains programs and projects to accomplish specific objectives of conservation and development. They provide for the full development of land presently used for farming. It is planned that such lands continue in their present use, with approximately 500 additional acres being added to cropland by 2020.

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000); and (c) distant future (2000-2020).

Program measures refer to onsite practices which take advantage of development made possible by the structural works of improvement, as well as measures for watershed protection, erosion control, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management practices, and irrigation development. Total cost of the program for the early action period is $20,828,000.

There are two early action projects described in Appendix XIV, Watershed Management. Primary agricultural benefits from these projects are prevention of flooding, and drainage improvement. The two projects are expected to cost $91,600 annually, and to result in annual benefits of $287,800 for a benefit to cost ratio of 3.1 to 1.

Three projects with an installation cost of $5,621,000 are proposed for after 1980, and three projects costing $1,310,000 will be installed after the year 2000. Program costs are expected to be $24,315,000 for the period after 1980 and $23,861,000 for the period after 2000. Total cost of the plan is expected to be $77,580,000.

A summary of the early action projects is given in Table 2-21 of the Puget Sound section on agriculture. A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, Watershed Management, Stillaguamish Basin section.

MINERALS

The locations of the known mineral deposits in the Basin are shown in Figure 7-14. The open circles on the map indicates properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

The Stillaguamish Basin has recorded production of sand and gravel, limestone, copper, silver, gold, and iron. Other mineral deposits that have been found in the area contain diatomite, peat, coal, pumice, asbestos, manganese, nickel, zinc, lead, and arsenic.

Limestone

Limestone occurs as pods, lenses, and beds in argillite, graywacke, and volcanic rocks of Paleozoic age. The deposits are located near Darrington, Arlington, Granite Falls, and Silverton, all of which are in the Snohomish County part of the Basin and are in the mountainous part of the area.

Limestone production began about 1934, and it is estimated that since that time, well over half a million tons of limestone worth over $1.5 million have been produced. Reserves are estimated to be in excess of 38.5 million tons. About 99 percent of the reserves are contained in the Galbraith and Bonanza Queen deposits, which are near Darrington and Silverton, respectively.

A breakdown according to size of deposit shows nine deposits with less than 10,000 tons each, three deposits with more than 10,000 but less than 1 million tons each, one deposit with more than 1 million but less than 10 million tons, and one deposit with more than 10 million tons.

Sand and Gravel

Good sand and gravel deposits occur in the glacial outwash of the western part of the area and in the river bars and terraces along the Stillaguamish River. The river bars are mostly west of Arlington and contain hard, well-rounded gravel.

Some 40 to 50 sand and gravel pits have produced aggregate or fill material at one time or

MINERAL PROPERTIES IN STILLAGUAMISH BASIN*

Explanation for Figure 7-14

Metallic Minerals
(with production or reserves data where available)

Arsenic (1 property)

Copper (38 properties)
46 – Bonanza Queen (prod.–830 tons)
49 – Mamie
48 – Ore Recoveries (prod.–200 tons)
45 – St. Louis and Jackson
44 – Wayside (prod. $500,000)

Gold (29 properties)
47 – Copper Independent (prod.–1 carload)

Iron (3 properties)
43 – Jefferson (prod.–6,000 tons)

Lead (1 property)

Manganese (3 properties)

Nickel (1 property)

Silver (4 properties)
50 – "45" (Magus) (prod.–3,185 tons)

Zinc (1 property)

Nonmetallic Minerals
(with reserves data where available)

Asbestos (1 property)

Coal (reserves–44.56 million tons)

Diatomite (2 properties)

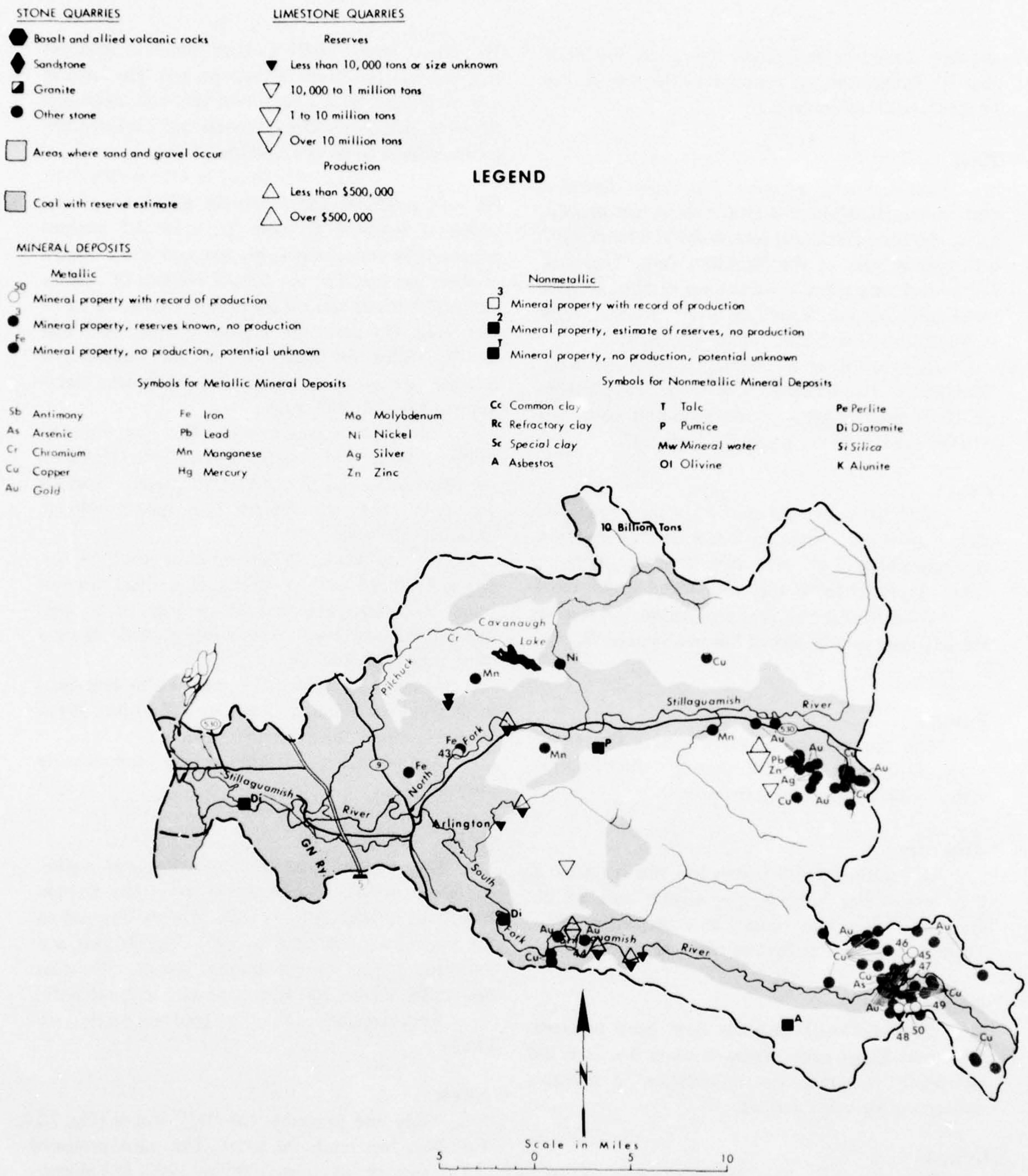
Pumice (1 property)

Stone Deposits

Limestone

Reserves
Less than 10,000 tons (9 properties)
10,000 to 1 million tons (3 properties)
1 million to 10 million tons (1 property)
More than 10 million tons (1 property)

*Some properties not plotted on map because of poor description of location and/or lack of space.



STILLAGUAMISH BASIN

MINERALS

FIGURE 7-14. Mineral resources in the Stillaguamish Basin

another. Complete production figures are not available for publication. No estimate of the reserves can be made, but they are large.

Coal

Coal occurs in two areas. The largest deposit is part of the Hamilton coal area. The smaller deposit, called the Rick Creek coal area, is about 4 miles south and slightly east of the Hamilton beds. The Rick Creek coal may be a continuation of the coalbeds that occur in the Hamilton area; however, their stratigraphic position is not definitely known.

There has been no production from either the Hamilton or Rick Creek beds. Reserves are estimated at 44.56 million tons in the Hamilton beds. No estimate is available for the Rick Creek coal.

Peat

At least a hundred peat bogs are known, the largest of which covers over 200 acres. Ten peat bogs covering a total of 687 acres have been investigated in detail. Seven of these bogs contain sphagnum moss.

There has been no peat production, but reserves are sufficient to take care of the area's demands.

Pumice

The one pumice property is near Oso and is reported to cover 20 to 25 acres. No other information is available concerning the deposit.

Asbestos

One occurrence of talcose asbestos is reported. It is near Clear Lake in the eastern part of the drainage system and occurs in a serpentine dike. There has been no production from the property.

Diatomite

Two diatomite deposits have been reported. One, near Kings Lake, is said to cover one acre, but no depth is given. No information is available concerning the other deposit.

Copper

The Wayside mine (Fig. 7-14, No. 44) has probably produced more copper than any other property in the Stillaguamish Basin. Total production has been about $500,000 worth of ore that contained 10 percent copper, 0.01 to 0.05 ounce of gold per ton, and 6 to 10 ounces of silver per ton. The ore is in a 6- to 18-inch-thick quartz vein that cuts slates and siliceous limestone. Ore minerals are chalcopyrite, pyrite, galena, sphalerite, and bornite.

Prior to 1918, the Bonanza Queen (Fig. 7-14, No. 46) produced approximately 830 tons of ore, which is reported to have averaged 3.5 percent copper, 0.04 ounce of gold per ton, and 2 to 3 ounces of silver per ton. The ore deposit consists of massive sulfides in lenses along a shear zone that is 10 to 75 feet wide. The zone cuts argillite country rock and can be traced for 3,000 feet on the surface. Ore minerals are pyrite, chalcopyrite, pyrrhotite, arsenopyrite, silvanite, and realgar.

The Ore Recoveries mine (Fig. 7-14, No. 48) shipped 200 tons of concentrates in 1940. Ore values ran between $3 and $7 per ton, 75 percent of which was gold. The ore deposit is a quartz vein in metamorphic rocks.

The St. Louis and Jackson mine (Fig 7-14, No. 45) is reported to have produced a small amount prior to 1909. The deposit consists of a well-mineralized quartz vein 1 to 6 inches wide along a shear zone in granite.

A small ore shipment is reported to have been made from the Mamie property (Fig.7-14, No. 49) in 1916. No other information is available.

Approximately 33 other copper properties are known.

Gold

No sustained gold production has been reported. One carload of picked ore from the Copper Independent Mine (Fig.7-14, No. 47) was shipped to the Everett smelter prior to 1901. The deposit is a mineralized shear zone in granite. The zone contains ore bodies 100 to 200 feet long and 2 to 3 feet wide.

Approximately 28 other gold properties are known.

Silver

Only one property, the "45" Magus (Fig. 7-14, No. 50), has produced silver. The mine produced 3,185 tons of ore from 1896 to 1902. Ore shipped returned 0.35 to 1.06 ounces of gold per ton and 48.4 to 171.4 ounces of silver per ton. The deposit is made up of mineralized fracture zones in meta-

morphic rocks. One vein has an indicated length of 3,000 feet. Ore minerals are galena, sphalerite, ruby silver, chalcopyrite, arsenopyrite, pyrite, pyrrhotite, marcasite, scheelite, and tetrahedrite.

Three other silver properties are known.

Iron

Of the three iron properties (Fig. 7-14), one has a record of production. The Jefferson mine (No. 43) yielded about 6,000 tons of bog ore that assayed 51 percent iron, 4.93 percent silica, and 0.02 percent sulfur. The iron bog is reported to be 2.5 to 3 feet deep and to cover 30 acres.

Other Properties in the Stillaguamish Basin

Other mineral properties that occur but which have no record of production include three manganese prospects and one prospect each of nickel, zinc, lead, and arsenic.

INTENSIVE LAND USE

Intensive land uses are found almost exclusively in the western one-third of the Basin, where, in 1960, 95 percent of the 12,680 people lived. There are three (3) incorporated municipalities, and approximately four unincorporated places.

INCORPORATED CITIES AND TOWNS

Arlington

The city of Arlington is in Snohomish County on the Stillaguamish River. First settled in 1864 and incorporated in 1903, Arlington, whose main industries are dairying products, food processing and wood products, is a trading center for the surrounding farming, dairying and logging area. The 1950 population of 1,635 had, by 1967, increased to 2,195.

Stanwood

The city of Stanwood, located in Snohomish County approximately 17 miles north of Evertt and 46 miles north of Seattle, was incorporated in 1903. Between 1960–1965, Stanwood merged with East Stanwood, incorporated in 1922, which accounts for the population increase from 646 in 1960 to 1,240 in 1967. Stanwood is the gateway to Camano Island in Island County, providing the only highway access to the island.

Granite Falls

The city of Granite Falls was incorporated in 1903 and had a 1967 population of 650. It is located in the Cascade foothills.

Unincorporated places include Silvana, Cicero, Bryant and Robe.

TRANSPORTATION

Rail—The area is served by the coastal routes of the Great Northern and the Northern Pacific Railroads.

Highway—Interstate Highway No. 5 crosses the basin from south to north. The main developed road up the valley is State Highway No. 530, and there are numerous other county roads.

Navigation—The Stillaguamish River, for navigation purposes, is limited to towing of logs, and to certain recreational uses within the tidal range.

Airways—Arlington has a municipal airport and there are some other smaller airfields within the Basins.

LAND USE CHARACTERISTICS

There are 433,627 acres of land within the Stillaguamish Basin, and 5,000 acres of inland water. Table 7-13 contains the figures showing the various amounts of major land use acreages within the Basin.

Figure 7-11 portrays the present land use for the Stillaguamish River Basin. It is easy to depict from the map of the Basin, the small acreages that are now being put to intensive use.

Intensive Land Use

At the present time (1967) intensive land uses occupy some 6,698 acres or 1.5 percent of the Basin's land area. Nearly all the intensive land use areas are located within or near the Basin's incorporated and unincorporated communities although a few intensive uses will be found at scattered locations throughout

the Basin. The following list contains land use figures for the intensive land use subgroups.

Railroads	Roadways	Airports	Urban (Built-up)	Total
471	3,978	506	1,743	6,698

Rural Nonagricultural

Many of the land uses classified within the Rural Nonagricultural category are similar in character and often associated with the forerunners of intensive land use and thus have been included for presentation in the intensive land use chapter. The following list shows the acreages in each of the subgroups in the rural nonagricultural category.

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm yards)	Total
1,602	---	738	3,592	5,932

Land Ownership

Of the total land area (433,627 acres) in the Stillaguamish Basin, 22.8 percent is in private ownership; 19.6 percent in private corporate ownership; 40.6 percent in federal ownership; 1.62 percent in State ownership; and .08 percent in local government ownership. The bulk of the private corporate, federal and state ownerships are forested areas located in the higher mountains. Land areas owned by local governments (city, county and special districts) are largely located in the western third of the Basin. These land areas are mainly related to intensive use, consisting of streets, facilities, local parks and similar areas. Other private ownerships are also located primarily in the western third of the Basin and consist mainly of intensive, rural nonagricultural and agricultural land areas.

TRENDS AND POTENTIALS

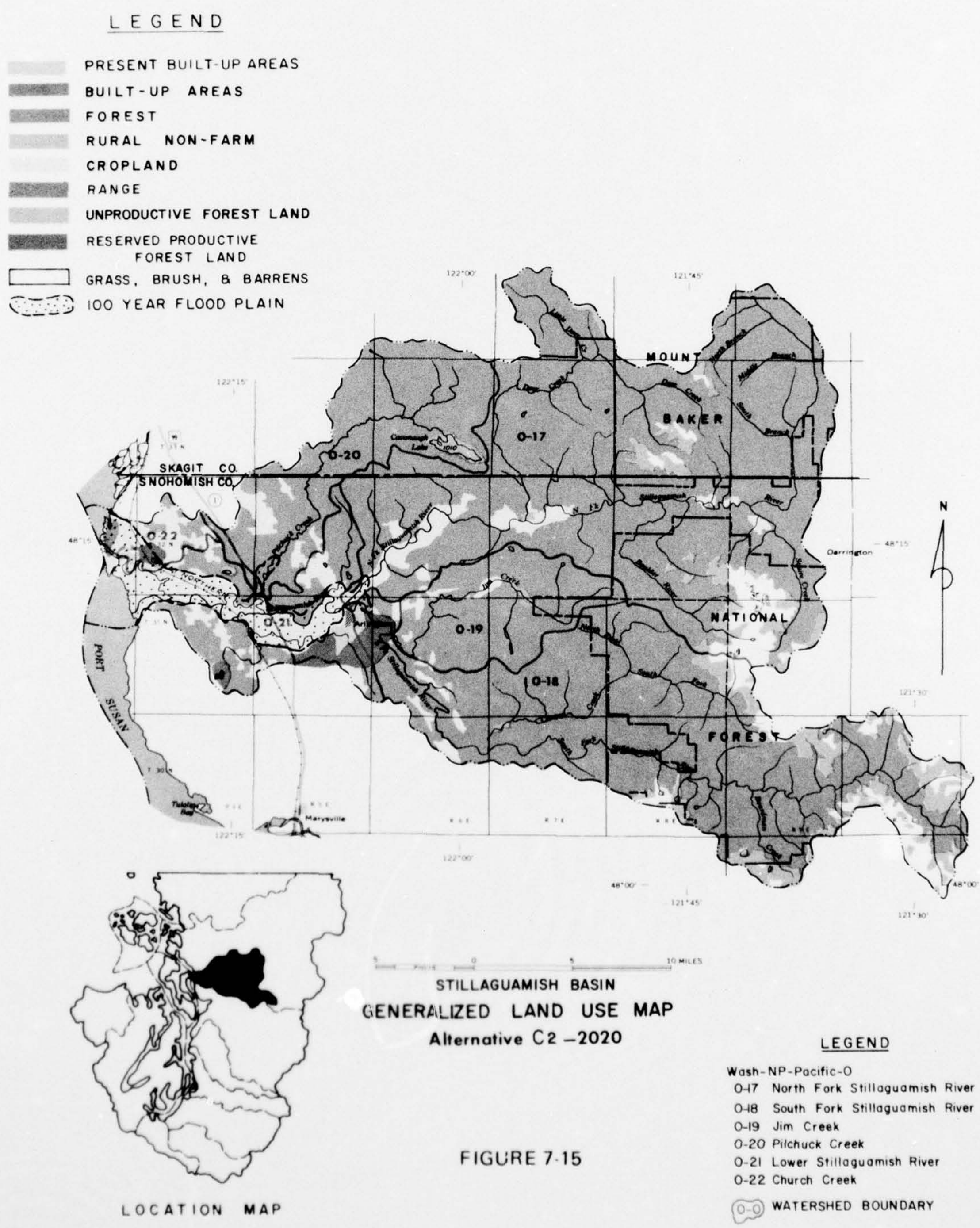
Intensive land use in the Stillaguamish Basin amounts to approximately 7,000 acres. This area totals less than one-half a township and accounts for approximately 1.6 percent of the Basin total. Within the Stillaguamish Basin there are some four (4) townships comprising some 92,000 acres which are considered most likely to receive pressure for intensive uses. These potential growth areas are located in the vicinity of the city of Arlington, running from the narrow Puget Sound shore portion of the Basin up to the Cascade foothills. Some flooding problems in the river valley area will limit the potential for intensive development, and indicates need for protection for continued agriculture use.

PRESENT AND FUTURE NEEDS

Future needs for land for intensive uses have been determined by two major factors. The first being the projected population for the Basin, the second being the density at which this population settles on the land. The 1967 population in the Basin was 18,300, with a density pattern of 2.4 persons per acre in the intensive land use areas. The population is projected to increase to 77,800 by the year 2020 with an increased density of 6.0 persons per acre, resulting in a total of 12,700 acres of land being put to intensive uses. With 92,000 acres of land deemed likely and suitable for future conversions and only 12,700 acres projected as actually required to fulfill this need by the year 2020, there will be a real need to guide development to those lands which are best suited for intensive uses, and to those areas where land use change will cause the least conflict between uses competing for land. The potential growth areas within the Basin are located in the vicinity of the city of Arlington, and should be guided southeast of the flood plain near the city. Figure 7-15 portrays the future land use pattern (C_2) for the Stillaguamish Basin for the year 2020.

By the year 1980, there will be an increase of only 11,900 in population, which will require only approximately 2,000 additional acres of land to be converted to intensive uses. By the year 2000, there will be a need for an additional 1,800 acres. The next twenty years to the year 2020, will produce a need for only 1,900 additional acres of land for intensive uses. Thus, by the year 2020, there will be only slightly more than 12,700 acres being put to intensive land uses.

The Stillaguamish Basin should be watched very closely in the latter part of the planning period (2020) as there is a good possibility that this Basin may receive a large spillover of population and, consequently, intensive land use from the developing

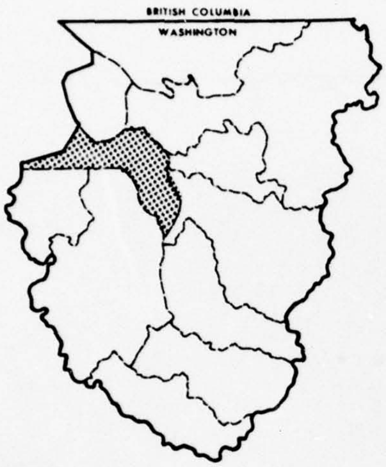


STILLAGUAMISH BASIN
GENERALIZED LAND USE MAP
Alternative C2 –2020

FIGURE 7-15

Everett-Seattle Metropolitan area to the south. This area, very likely. may become the distant suburb to this growing metropolitan area, especially if rapid transit were to be developed to serve the area. This is a factor that should be considered when this study is reviewed in future years.

WHIDBEY-CAMANO ISLANDS



Whidbey-Camano Islands are located in the north sector of the Puget Sound Area. These islands occupy a major portion of the area west of Everett and east of Port Townsend at the entrance to lower Puget sound. The hydrologic area of 133,654 acres lies within Island County and is entirely surrounded by salt water. There are no rivers in the area and the small streams and lakes do not provide significant water production in the Puget Sound Area.

Population

The population of the Basin in 1967 was 22,400 persons. Projections show that the population will grow to 26,900 by 1980, 36,200 by 2000 and 49,500 persons by the year 2020. If a bridge is constructed between the mainland and Whidbey Island, the population will increase to over 115,000 by the year 2020.

Land Use

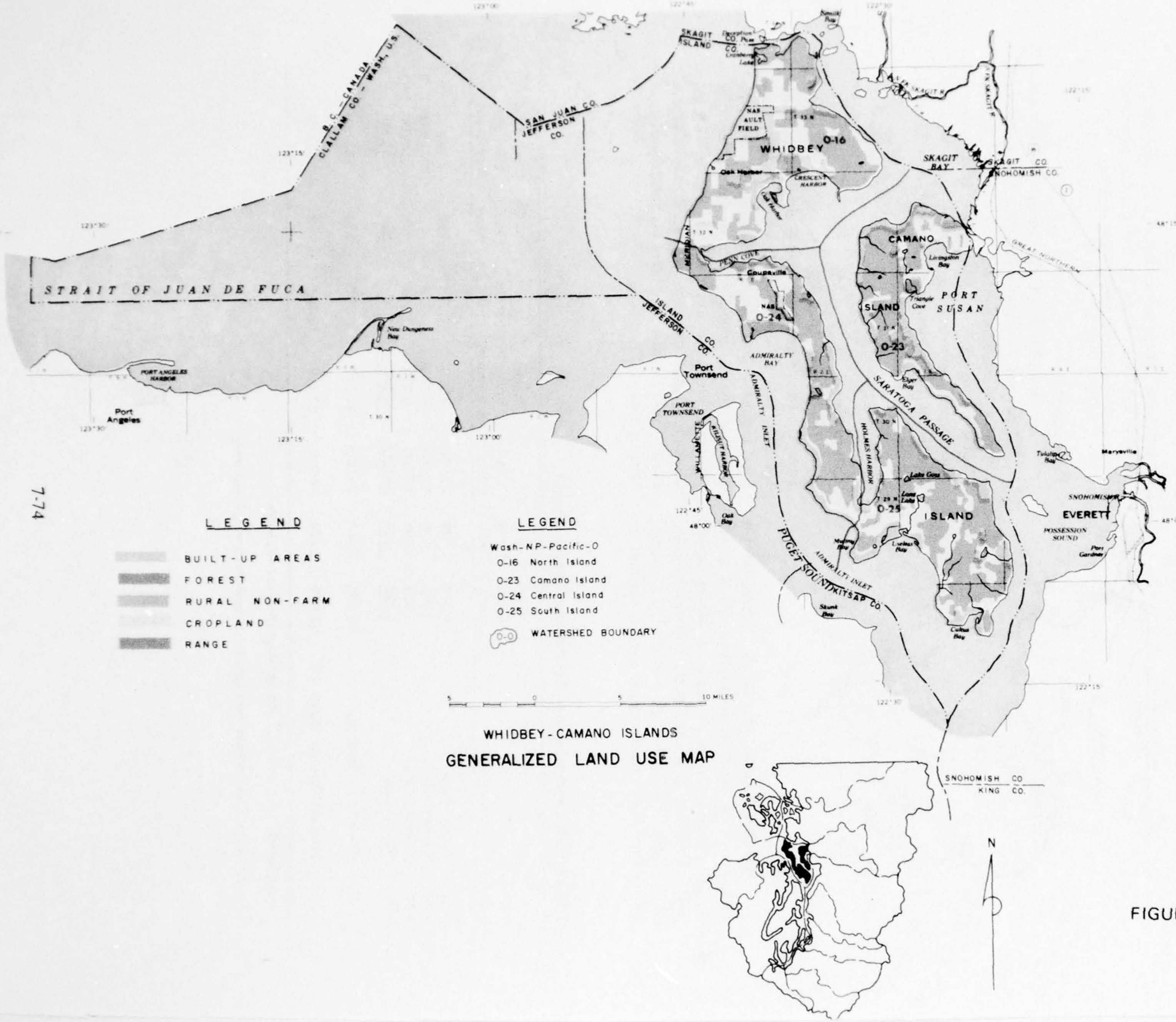
The primary land use in the Whidbey-Camano Islands is forests and associated lands which accounts for over 60% of the total. The other two primary uses, croplands and intensive uses, occupy 17% and 8% respectively. Table 7-19 shows the tabulation of the present land use on the Islands. Figure 7-16, the generalized land use map of the Whidbey-Camano Islands, portrays the land areas occupied by each of the major uses.

TABLE 7-19. Land use in Whidbey-Camano Islands (acres)[1]

Map No.	Watershed	Crop-land	Range-land	Total Forest[2]	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
0-16	North Island	9,374	679	20,220	2,276	7,923	259	40,731
0-23	Camano Island	2,897	539	17,966	3,183	679	60	25,324
0-24	Central Island	5,607	1,108	19,263	3,214	1,118	76	30,386
0-25	South Island	5,128	128	26,620	3,746	1,267	324	37,213
	Total Pacific Drainages	23,006	2,454	84,069	12,419	10,987	719	133,654
	Whidbey-Camano Islands	23,006	2,454	84,069	12,419	10,987	719	133,654

[1] Unadjusted measurements, 1966, for Puget Sound Area Study.

[2] Figures include nonforested land commonly associated with forest areas.



WHIDBEY - CAMANO ISLANDS
GENERALIZED LAND USE MAP

FIGURE 7-16

AGRICULTURE

PRESENT STATUS AND POTENTIAL

The Whidbey-Camano Islands study area comprises all of Island County. It is located at the northern end of Puget Sound, off the coast of Skagit and Snohomish Counties. Two large islands and three small islands combine to form the Whidbey-Camano Islands group. The major islands are Whidbey, the largest and most important, draining an area of 169 square miles; and Camano, draining an area of 40 square miles. The three smaller islands are Ben Ure, Strawberry, and Smith.

All of the land area of 132,935 acres in the Whidbey-Camano Islands has been mapped in a medium-intensity soil survey, as no national forest lands are found within the study area. Of the 132,935 acres so mapped, approximately 125,000 acres are classified in Land Use Capability Classes II through VI.

These 125,000 acres have the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, and IV are suited for either cropland or urban uses, and Class VI has potential for urban developments.

The Whidbey-Camano Island study area provides the second smallest valley system in the Puget Sound Area. It drains a total area of only 210 square miles. Drainage is accomplished by minor streams that flow directly into Puget Sound. The system includes several flood and drainage problem areas which require corrective measures before their potential can be attained. Most of the land is generally undulating to gently rolling, although there are a few slopes steeper than 15 percent.

Production

Farming is concentrated largely in the northern half of Whidbey Island. Shifts in land use have not been extreme. The raising of beef cattle has more or less replaced dairying. The raising of hay, wheat, oats, vegetables, and other specialized crops is highly important in the area's economy. The total number of farms and acreage has decreased, with lands formerly cropped being taken over by the military and naval sites. Total value of farm production in the Whidbey-Camano Islands is almost $3 million annually.

Forest lands are the largest user of land in the Islands. Lumbering is a significant factor in the economy of the Islands. Forested lands, including associated open areas, comprise 84,000 acres.

Flooding

Topographic and climatic conditions induce only one floodproducing season annually. It comes in the fall or winter as the result of excessive precipitation. Discharges in excess of channel capacity cause water to spread across the valleys, where it remains until the streams drop. In some areas, water is trapped by topographic detail until it can seep into the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV. Principles and conditions discussed therein apply to the Whidbey-Camano Islands and need not be repeated here.

Watersheds

Four watershed areas requiring solutions to problems, or development to achieve potential productivity of the Whidbey-Camano Islands, are shown on the Land Use Map (Figure 7-16) and on the Land Capability map (Figure 7-17).

North Whidbey Island watershed (0-16) is the major cultivated farming area of the Islands. Approximately half of the area is in forest or brush which has replaced the native forest. Many summer homes and beach homes are being built and the area is rapidly becoming urbanized. Potential use would seem to lean toward greater urbanization, with farming continuing to be very important.

Central Whidbey Island watershed (0-24) contains approximately 30,000 acres. A portion of the area is reasonably level and is adaptable to farming. Much of the area is very rough, however, and about two-thirds is forested. Built-up areas are not too prevalent, although Coupeville (the county seat of Island County) is located in this watershed. Potential use would seem to be in further development of forested lands and croplands.

South Whidbey Island watershed (0-25) has some cultivated land but the majority of the area is rough, rocky terrain, unsuitable for cultivation. Approximately three-fourths of the Island is timbered, with some commercial timber remaining. Urbanization, although still sparse, is on the increase. Potential use would appear to be for summer homes and country living. Logging and farming will probably continue to be important in the economy of the watershed.

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Camano Island watershed (0-23) is largely covered by timber in various stages of growth. Some small areas have been cleared and are in pasture, with a minor amount of cultivated farmland. As in the other watersheds, there is continued construction of summer homes. Potential use would seem to be as a location for summer homes and recreation, with forestry and farming playing minor parts.

Many of the farmlands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions are summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the Whidbey-Camano Islands is shown in Table 7-19. The following tables are to indicate the potential development possible within acceptable land use standards.

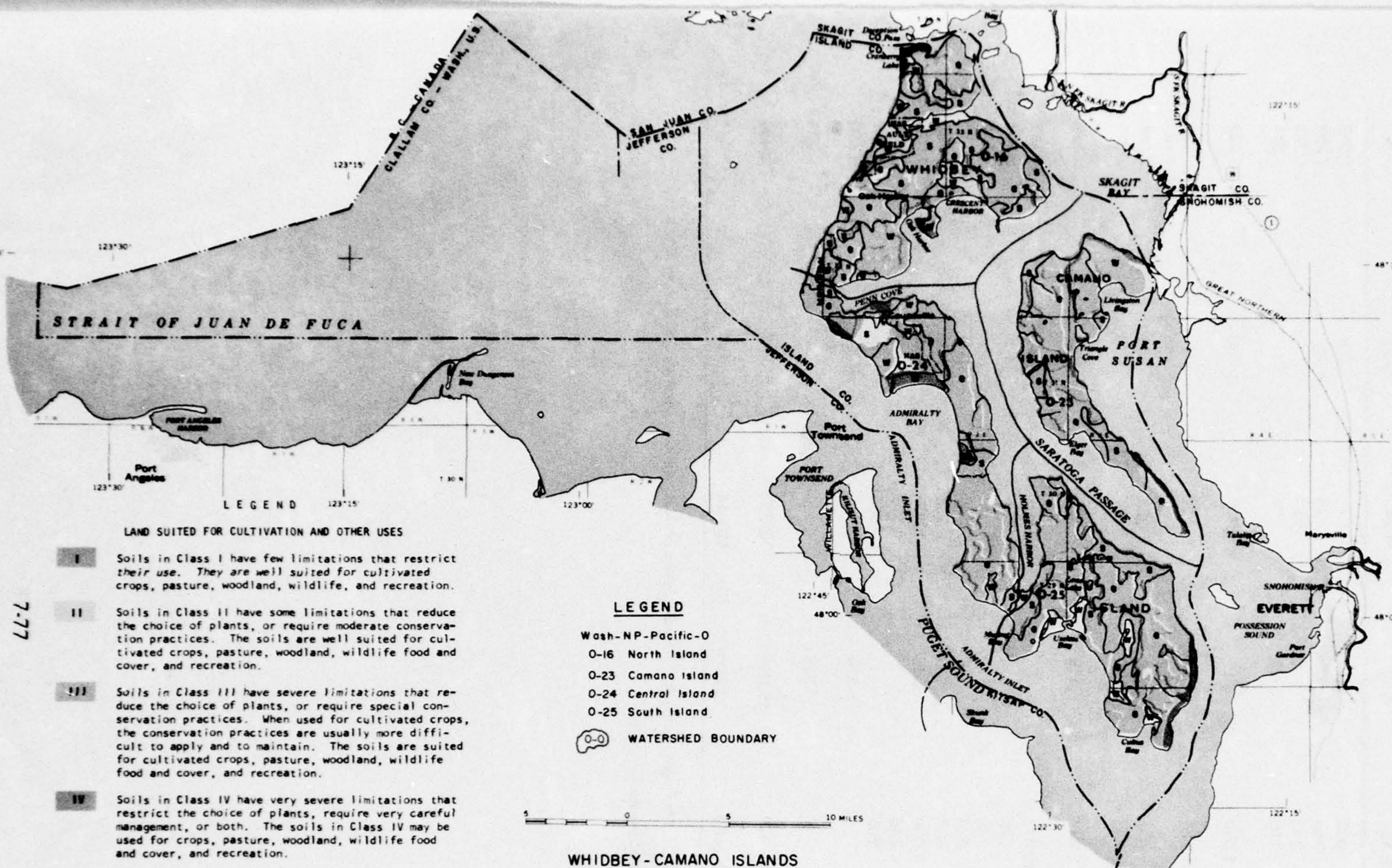
Table 7-20 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-21 shows the number of acres in each capability class, subclass, and unit, by watersheds, in the Whidbey-Camano Islands. This table can be used with the description of capability units to estimate the potential for development.

TABLE 7-20. Distribution and value of production by crops in Whidbey-Camano Islands

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	1,660	2,190	9.52	105,676	6.63
Field crops	84	111	.48	33,158	2.08
Vegetables	423	558	2.42	119,727	7.51
Berries	37	49	.21	50,561	3.17
Nursery products	110	145	.63	252,921	15.87
Cropland not used	1,086	1,433	6.23	--	--
Sub-Total	3,400	4,486	19.49	562,043	35.26
Hay	6,186	8,162	35.48	382,578	24.00
Hay aftermath	--	--	--	--	--
Sub-Total	6,186	8,162	35.48	382,578	24.00
Silage (grass)	947	1,249	5.43	82,751	5.19
Grass aftermath	--	--	--	--	--
Sub-Total	947	1,249	5.43	82,751	5.19
Silage (corn) fodder	29	38	.17	2,515	.16
Pasture (cropland)	6,875	9,071	39.43	563,928	35.39
Sub-Total	14,037	18,520	80.51	1,031,772	64.74
Total	17,437	23,006	100.00	1,593,815	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.



LEGEND

LAND SUITED FOR CULTIVATION AND OTHER USES

I	Soils in Class I have few limitations that restrict *their use. They are well suited for cultivated* crops, pasture, woodland, wildlife, and recreation.
II	Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
III	*Soils in Class III have severe limitations that re*duce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
IV	Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

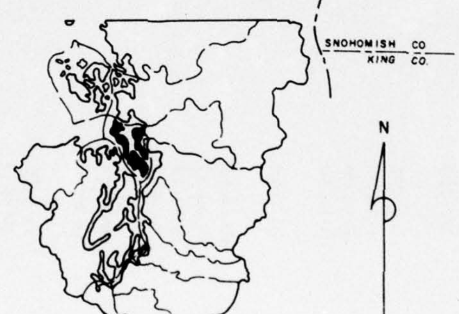
LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

V	Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.
VI	Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.
VII	Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.
VIII	Soils and land forms *in Class VIII have limitations* that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

WHIDBEY-CAMANO ISLANDS
GENERALIZED
LAND CAPABILITY MAP
Class and Subclass



LOCATION MAP

FIGURE 7-17

TABLE 7-21. Land capability units in Whidbey-Camano Islands (acres)[1]

Capability Units[2]	WATERSHEDS 0-16	0-23	0-24	0-25	Total
II ws 04	502	353		788	1,643
II ws 06	966	108	74	942	2,090
II ws 12	243	8	812		1,063
II ws 03	118	22	511		651
II Total	1,829	491	1,397	1,730	5,447
III ew 01	101	24	31		156
III ws 03		157		30	187
III ws 09	1,076	288	357	887	2,608
III ws 10	2,465	650	97	66	3,278
III Total	3,642	1,119	485	983	6,229
IV ew 03	10,571		11,681	15,862	38,114
IV ew 12	325	954	669	196	2,144
IV ew 22	50	9,436	33		9,519
IV es 10	514	6	200	5	725
IV ws 06	634	153	128	338	1,253
IV ws 11	1,090	1,846	1,562	120	4,618
IV ws 43	1,246		196	7	1,449
IV so 10	968		563		1,531
IV se 05		2,310			2,310
IV se 11			30		30
IV sw 09		335			335
IV Total	15,398	15,040	15,062	16,528	62,028
II-IV Total	20,869	16,650	16,944	19,241	73,704

1 Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2 See Exhibit 1 for description of capability units.

TABLE 7-21. Land capability units in Whidbey-Camano Islands (acres) [1] (cont.)

Capability Units [2]	WATERSHEDS 0-16	0-23	0-24	0-25	Total
VI ew 21		2,572			2,572
VI ew 26	4,392		1,918	3,116	9,426
VI ew 28	25		117	5	147
VI es 17	20		5		25
VI es 19		2,658			2,658
VI es 22	1,653	75	1,759	5,546	9,033
VI ws 02	121		241	65	427
VI so 12	1,162		3,565	860	5,587
VI so 13	9,186		2,330	792	12,308
VI so 18		300			300
VI so 21	135		849		984
VI se 13	844		565	5,412	6,821
VI se 17		1,151			1,151
VI Total	17,538	6,756	11,349	15,796	51,439
VII es 29			55	230	285
VII es 36	589	1,026	549	967	3,131
VII Total	589	1,026	604	1,197	3,416
VIII ew 39	654	443	461	484	2,042
VIII ws 22	53	20	944		1,017
VIII ws 23	101	316		126	543
VIII ws 24	54			45	99
VIII so 00	614	53	8		675
VIII Total	1,476	832	1,413	655	4,376
VI-VIII Total	19,603	8,614	13,366	17,648	59,231
II-VIII Total	40,472	25,264	30,310	36,889	132,935

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

[2] See Exhibit 1 for description of capability units.

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the Whidbey-Camano Islands will increase from 22,400 persons in 1967 to approximately 49,500 people by 2020, according to Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 23,406 acres presently in intensive and rural nonagricultural use could provide ample acreage for new intensive development to the year 2020 without an encroachment onto the croplands of the Islands.

Cropland Needs

The Islands presently have 23,006 acres of cropland. Losses to other uses are expected to cause a decrease in cropland, leveling off to about 20,000 acres by 2020. Percent increases needed by crop for the Puget Sound Area are shown on Table 2-15.

Protection and Development Needs

Data in Table 7-22 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Whidbey-Camano Islands is summarized under the topic "Program Implementation" immediately following "Forestry." A more complete description is found in Appendix XIV, Watershed Management.

TABLE 7-22. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	20,000	20,000	20,000
Watershed protection and rehabilitation[2]	acre	24,960	24,210	22,454
Drainage improvement	acre	8,632	14,387	19,182
Irrigation development[3]	acre	3,500	5,000	10,000
Water for irrigation[4]	ac.ft.	9,590	13,700	27,400

[1] A total of 25,566 acres in the Whidbey-Camano Islands are subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated here.

[2] Includes 2,454 acres of rangeland.

[3] According to Appendix VII, Irrigation, there were 2,700 acres (using 7,398 feet of water) irrigated in 1966. Irrigation Appendix projections show that irrigation will decline in future years in the Islands.

[4] Based on gross diversion requirements of 2.74 acre-feet per acre, estimated by Irrigation Committee in Appendix VII, Irrigation.

FORESTS

PRESENT STATUS

Most of the land area is forest covered with 66%, or 89,380[1] acres, classified as forest land (Table 7-23). These lands are scattered throughout the Island areas. Only 4,800 acres of forest land is officially designated as reserved, this mainly in State holdings. The remaining forest land is classified into zones below.

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	81,240	96
Principal Forest	3,320	4
Upper Forest	--	0
Subalpine	--	0
Total forested land	84,560	100

[1] Does not include nonforested lands commonly associated with forest areas.

TABLE 7-23. Whidbey-Camano Islands—Area of forest land, in acres, by ownership and type

Cover Type of Land Class	Other Federal (Available)	Municipal (Available)	Private (Available)	Total Available	Unavailable	Total Available & Unavailable
Douglas-fir						
seedlings and saplings	--	--	4,470	4,470	60	4,530
poletimber	--	10	19,310	19,320	160	19,480
small young growth sawtimber	430	10	34,160	34,600	2,550	37,150
old growth and large young growth sawtimber	870	--	1,480	2,350	1,590	3,940
Western hemlock						
seedlings and saplings	--	10	--	10	-	10
poletimber	--	--	4,470	4,470	40	4,510
Western redcedar						
poletimber	--	--	2,980	2,980	10	2,990
small sawtimber	--	--	1,480	1,480	--	1,480
SUBTOTAL, softwoods	1,300	30	68,350	69,680	4,410	74,090
Hardwoods						
poletimber	--	--	8,920	8,920	30	8,950
small sawtimber	--	--	4,470	4,470	90	4,560
large sawtimber	--	--	1,490	1,490	290	1,780
SUBTOTAL, hardwoods	--	--	14,880	14,880	410	15,290
TOTAL all forested land	1,300	30	83,230	84,560	4,820	89,380

TABLE 7-24. Whidbey-Camano Islands—Volume of sawtimber and growing stock, by ownership, on productive forest land

Species or Group	Available				Unavailable	Total Available & Unavailable
	Other Federal	Municipal	Private	Total Available		
Sawtimber—Thousand board feet, International ¼-inch Rule						
Douglas-fir						
small sawtimber	6,040	160	503,430	509,630	30,550	540,180
large sawtimber	40,450	20	104,850	145,320	57,720	203,040
Western hemlock						
small sawtimber	--	--	5,990	5,990	60	6,050
large sawtimber	--	10	5,990	6,000	60	6,060
Western redcedar						
small sawtimber	--	--	27,320	27,320	10	27,330
large sawtimber	--	--	4,110	4,110	20	4,130
SUBTOTAL, softwoods	46,490	190	651,690	698,370	88,420	786,790
Hardwoods						
small sawtimber	--	--	51,910	51,910	1,020	52,930
large sawtimber	--	--	54,720	54,720	10,600	65,320
SUBTOTAL, Hardwoods	--	--	106,630	106,630	11,620	118,250
TOTAL sawtimber, all species	46,490	190	758,320	805,000	100,040	905,040
Growing Stock—Million cubic feet						
Douglas-fir	8.5	0.0	110.8	119.3	16.1	135.4
Western hemlock	--	0.0	2.3	2.3	0.0	2.3
Other softwood species	--	--	12.4	12.4	0.0	12.4
SUBTOTAL, softwoods	8.5	0.0	125.5	134.0	16.1	150.1
Hardwoods	--	--	42.1	42.1	4.6	46.7
TOTAL growing stock, all species	8.5	0.0	167.6	176.1	20.7	196.8

Unlike the other Basins in the Puget Sound Area, Whidbey-Camano Islands are not classified into commercial and noncommercial forest land. The forest land area of 84,560 acres supports a sawtimber volume of 805 million board feet, International ¼-inch Rule (Table 7-24). These figures represent about 1.6% of Puget Sound Area's commercial timber area and less than 1.0% of its timber volume. Privately owned lands make up 83,230 acres, or 90% of the forest land, and 93% of the total Island area. Large private holdings of 1,990 acres do not provide a significant timber producing base. There are no medium sized private holdings, but small private areas total 81,240 acres, practically all of it in woodlands and woodlots. Public ownership of forest land is recorded as 1,300 acres Federal and 30 acres municipal with no State lands in this class.

The forest products industry on Whidbey-Camano Islands is scattered throughout the area. All six manufacturing plants listed in 1964 are designated as sawmills with a total production of 80,000 board feet per day. Products are lumber, moulding, car stock, fencing, and other specialties.

These Islands are considered to be a recreation and expansion area for the metropolitan areas of Seattle and Everett. Problems affecting forest land management are remote except for those relating to natural beauty and fire control. This area was heavily

cut-over during the late 1880's and does not contain sufficient stands of merchantable timber needed to sustain industrial operations of any size. Forest products industries are not likely to have problems, or create any, due to limitations of land use plans which are being developed in the interest of residence rather than commercial outlet.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

Future development of the forest products industries and management of forest lands for timber production are expected to be very limited in the Whidbey-Camano Islands. These lands have a high potential for recreation development and, in addition, are highly attractive for the private development of summer homes, resorts, or similar forms of land use. The current ownership pattern, as well as expected changes in ownership, suggests that timber production will not be practiced on any significant scale. It is therefore assumed that the forest area of the Whidbey-Camano Islands will be wholly removed from commercial timber production by the year 2020.

The conversion or reservation of forest land for other purposes will not occur overnight, however. In the interim, some timber will be marketed from sporadic cutting of the predominantly second growth stands and as a result of land clearing operations. The volume is expected to be small, however, due to the pattern of small ownerships and small size of the timber involved.

Since commercial timber cutting is expected to be limited, there will be little need for the watershed protection measures suggested for such operations. The expected land use pattern will emphasize aesthetic appearance, therefore it is assumed that the land owners will perform any needed erosion control or other work that will be necessary in maintaining these values.

PROGRAM IMPLEMENTATION AGRICULTURE AND FORESTS

In order to satisfactorily take care of the needs of Whidbey-Camano Islands, as explained in the preceding pages, the following plan has evolved. It is multipurpose in scope and will provide for floodwater prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development. Other measures provide for water quality and quantity control, recreation, and fish and wildlife development.

This plan includes programs and projects designed to accomplish specific objectives of conservation and development. They provide for the full development of lands presently engaged in farming. It is planned that most of these lands will retain their present use, although approximately 3,000 acres are expected to be lost to other uses.

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000): and (c) distant future (2000-2020).

Program measures refer to onsite practices which take advantage of development made possible by the strucutural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management practices, and irrigation development.

All of the projects planned for the Whidbey-Camano Islands fall into the 1980-2000 category. Four such projects are planned, with a total installation cost of $3,245,000.

Total cost of the program for the early action period is $5,793,000. Program costs are expected to be $8,313,000 for the period after 1980, and $8,676,000 for the final time period. Total cost of the plan is expected to be $26,027,000.

A presentation of the proposed plan, including Agriculture, can be found in Appendix XIV, Watershed Management, Whidbey-Camano Islands section.

Current and projected commercial forest area in the Whidbey-Camano Islands 1965-2020 (in thousand acres)

	Ownership					
	Private			Public		
Period	Large	Medium	Small	Federal	Other	Total
1965	2.0	--	81.3	1.3	--	84.6
1980	1.0	--	54.5	--	--	55.5
2000	--	--	8.1	--	--	8.1
2020	--	--	--	--	--	--

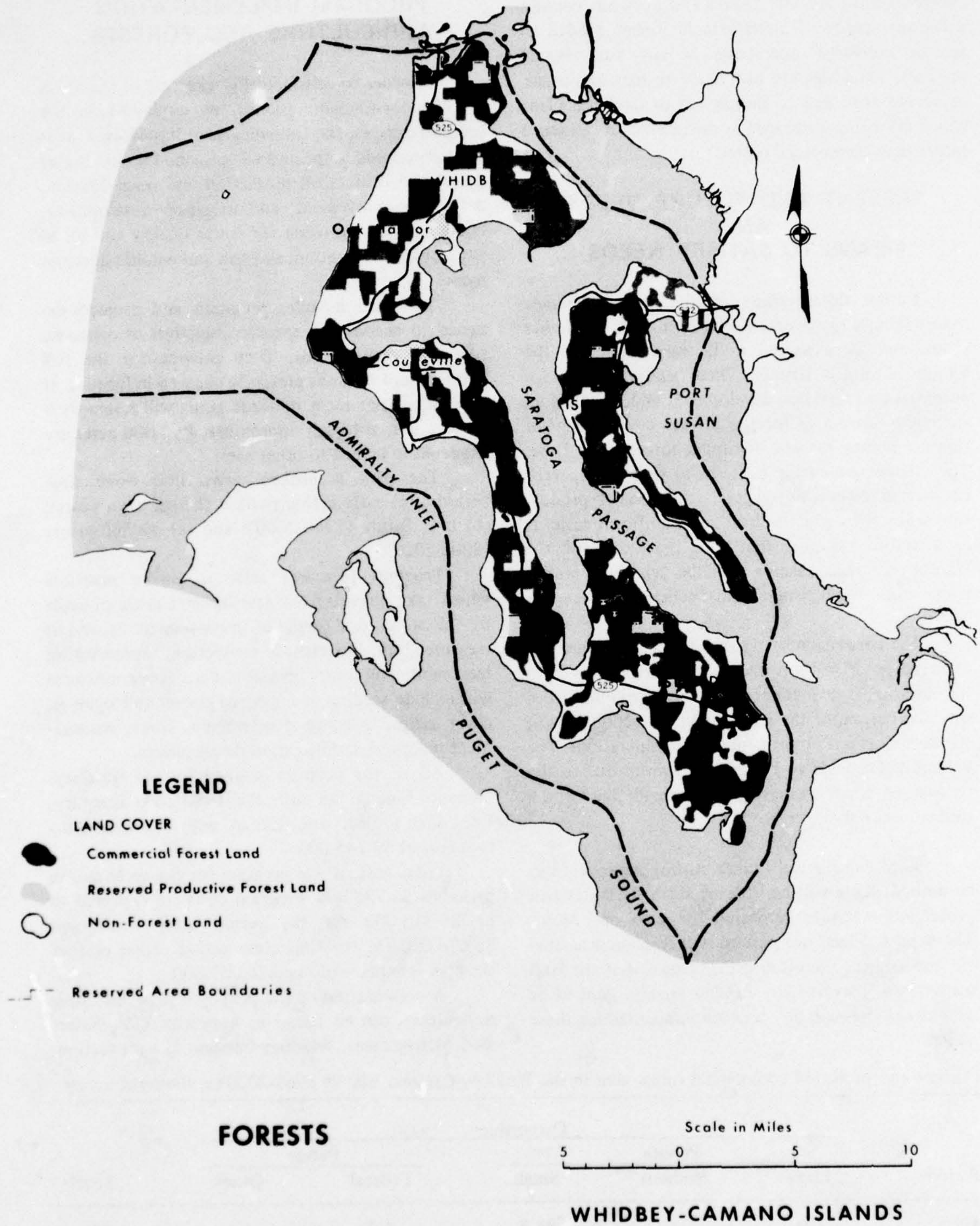


FIGURE 7-18. Forest lands in the Whidbey-Camano Islands

MINERALS

The locations of the known mineral deposits in the Islands are shown in Figure 7-19. The open circles on the map indicates properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

Mineral deposits known to occur in the Whidbey-Camano Islands are sand and gravel, peat, and diatomite.

Peat

Thirteen peat bogs covering 1,949 acres have been investigated. Of these, six contain sphagnum peat. The largest bog covers 792 acres, and one bog, at Cranberry Lake, has sphagnum to a depth of 45 feet.

There is one peat producer. Statistics on peat production are not available for publication, and there is no estimate of reserves. Reserves, no doubt, are sufficient to supply the area's needs for many years.

Sand and Gravel

Almost the entire Whidbey-Camano Islands area is covered by glacial deposits (Fig. 7-19) that in places contain sand and gravel suitable for commercial use. At least 11 pits have a record of production. Currently (1966), three companies are producing sand and gravel from the area. No estimate of reserves is available.

Diatomite

One diatomite deposit is reported, but no information other than its location is available. The location of this deposit is shown on Figure 7-19.

INTENSIVE LAND USE

This Basin is composed of Whidbey and Camano Islands, which make up Island County, and is located in Puget Sound, just west of Skagit and Snohomish Counties. Except where the channel narrows, at its northerly end at Deception Pass, which has a bridge connection to the mainland, Whidbey Island is separated from the mainland by deep saltwater channels two miles or more in width. Camano Island, separated from the mainland by a narrow slough bridged near Stanwood, has a good road completely around it, and shores well developed with residential homes for permanent and recreational use.

Recreational opportunities are numerous with the Islands' long coast lines and sheltered bays and beaches. While land use shifts on the Islands have been minimal, increases in recreation uses and summer and suburban residences are apparent.

Although the economy is based on agriculture, lumbering, recreation, and military establishment, Whidbey Island's population increase of 82 percent between 1940-1950 was primarily related to establishment of military bases at Oak Harbor and Crescent Harbor. Within the Islands, there are three incorporated municipalities and approximately seven unincorporated places.

A note of interest is that less than a third of the population of the Islands is reported in incorporated towns.

INCORPORATED CITIES AND TOWNS

Oak Harbor

The city of Oak Harbor is in Inland County on the north end of Whidbey Island and is the largest town on the Island. When incorporated in 1915, logging, farming and fishing were the major industries. In 1941, however, the United States Navy established the Whidbey Island Naval Air Station which has since been the main income source and growth catalyst for Oak Harbor. A seaplane base faces the mainland and a landplane base, Ault Field, faces the Strait of Juan de Fuca. In additon to being the trading center for the Island, Oak Harbor has a good beach, boating and fishing facilities.

Population of Oak Harbor in 1950 was 1,193 and increase 230.4 percent between 1950 and 1960, and by 1967 had reached 5,100.

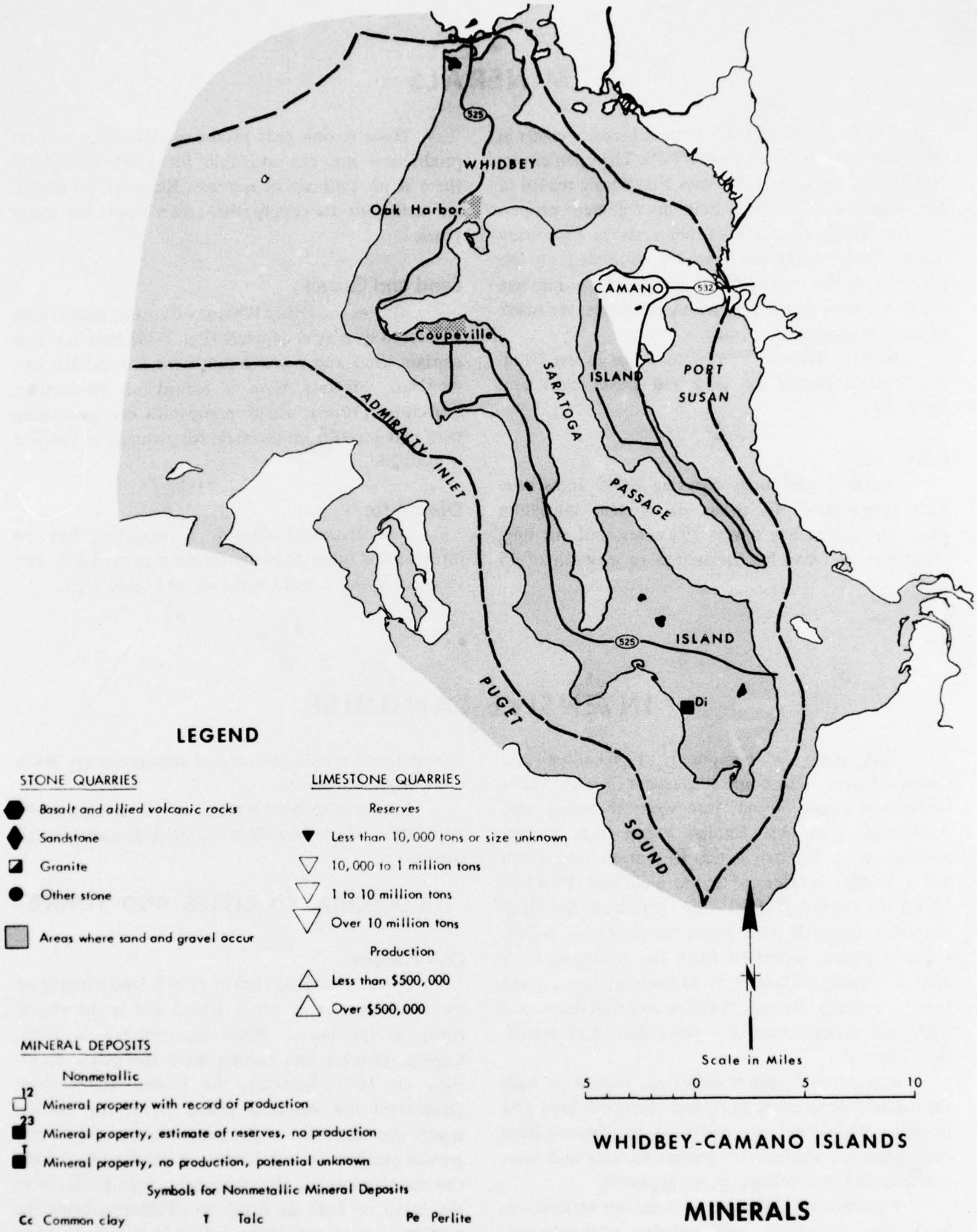


FIGURE 7-19. Mineral resources in the Whidbey-Camano Islands

Coupeville

The town of Coupeville was incorporated in 1910 and had a 1967 population of 675. It serves as the county seat of Island County.

Langley

The town of Langley was incorporated in 1913 and had a 1967 population of 472.

Unincorporated places include San Juan de Fuca, Utsaladdy, Camano, Keystone, Greenbank, Freeland, and Clinton.

TRANSPORTATION

Highways–The major highway is State Highway 525, running the length of Whidbey Island. State Highway 532 runs the length of Camano Island. Some secondary roads also traverse the major islands. Whidbey Island is accessible by vehicular traffic from the mainland via Deception Pass bridge.

Airways–The only airfield is at Oak Harbor. It is limited to use by military aircraft.

Navigation–Navigation is mostly limited to ferryboats and pleasure crafts. The Islands have only minor port facilities.

LAND USE CHARACTERISTICS

There are 132,935 acres of land within the Whidbey-Camano Islands and 719 acres of inland water. Figure 7-16 portrays the land use picture for the Islands at the present time. Table 7-19 contains the acreage figures showing the various amounts of land classified in each major land use on the Islands.

Intensive Land Use

At the present time (1967) intensive land uses occupy some 10,987 acres of 8.3 percent of the Islands' land area. Due to the recreational, summer home and suburban residential development, there are many intensive uses scattered throughout the Islands. The following list contains the land use figures for the intensive land use subgroups.

Railroads	Roadways	Airports	Urban (Built-up)	Total
0	3,088	4,000	3,299	10,987

Rural Nonagricultural

Since many of the land uses classified within the Rural Nonagricultural category are similar in character and often associated with or the forerunners of intensive land use, they have been included in the intensive land use chapter for the convenience of the reader. The following list describes the acreages in the several subgroups of the Rural Nonagricultural category.

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm yards)	Total
9,687	1,161	133	1,438	12,419

Land Ownership

Of the total land area (132,935 acres) in the Whidbey-Camano Islands, 80 percent is in private ownership; 6.6 percent in private corporate ownership; 6.9 percent in Federal ownership; 4.2 percent in State ownership; and 2.3 percent in local government ownership. The bulk of the Federal ownership is military establishments, while land areas owned by local governments (city, county and special districts) are mainly related to intensive use consisting of streets, facilities, local parks and similar areas. Other (nonforest) private ownerships cover several land use areas; intensive, rural nonagricultural, agricultural and forests.

TRENDS AND POTENTIALS

Intensive land use in the Whidbey-Camano Islands amounts to some 10,981 acres or approximately one-half of a township of land. This area accounts for 8 percent of the total Island's area. Present intensive land use requirements are being filled at several locations–mainly in and around Oak Harbor and Coupeville. Scattered intensive use of a mainly residential nature occur throughout the Islands particularly on or near waterfront lands. Also located in the Islands is the Whidbey Island Naval Air Station, providing the major source of employment in the Islands. Within the Whidbey-Camano Islands there are approximately two (2) townships comprising 46,000 acres which are likely to receive pressure to be converted to intensive uses. Pressures exerted by the growth of the Seattle metropolitan area will likely cause considerable conversion of land to intensive

uses, particularly for permanent and vacation residential purposes.

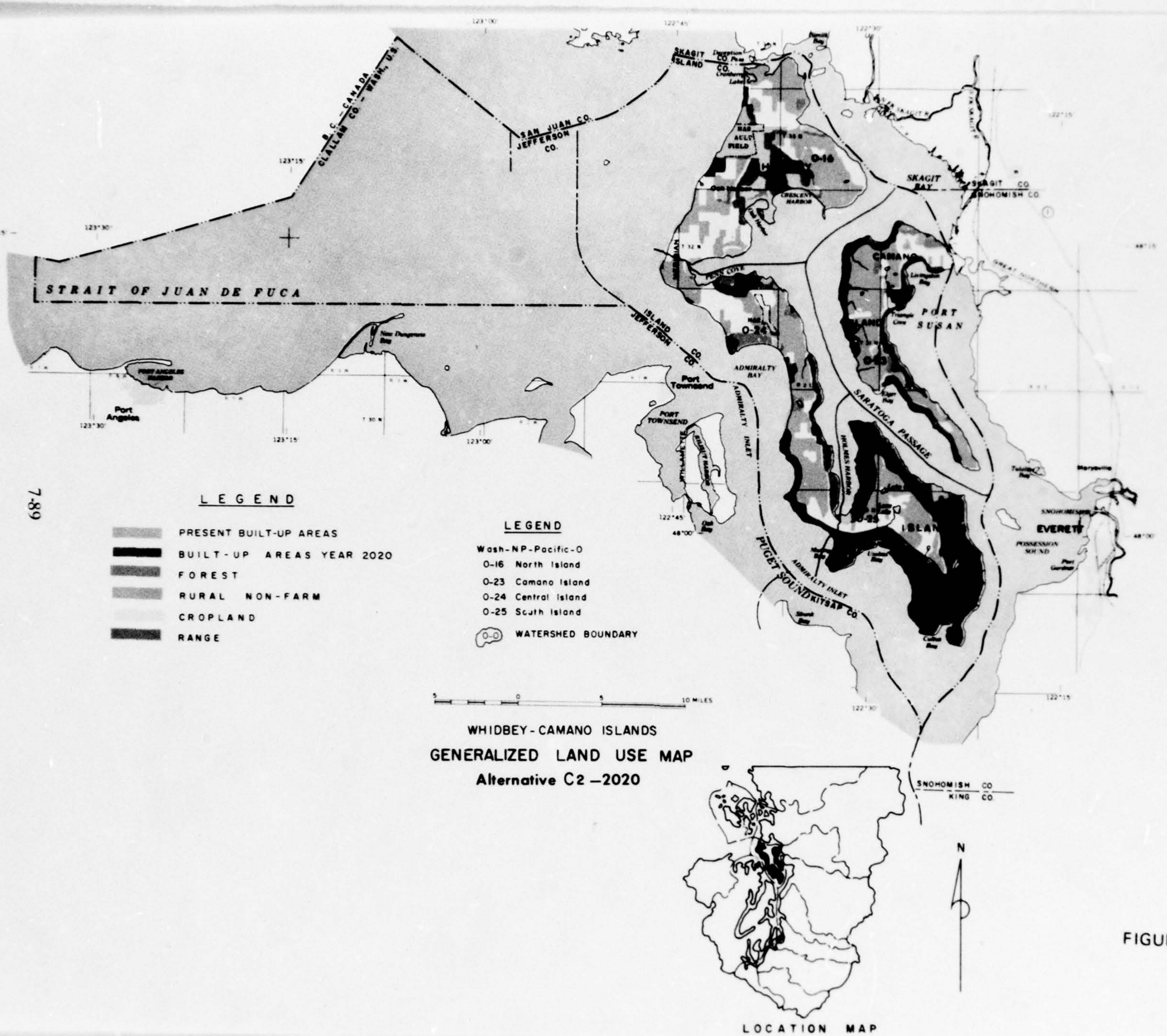
PRESENT AND FUTURE DEMANDS

Present trends of intensive land use on Whidbey and Camano Islands reveal that vacation homes and residential homes account for much of the total acreage in this use. This trend will continue on through the planning period, with a greater percentage of the now part-time residential development becoming permanent residents in the latter part of the projection period. This trend will be accelerated if a bridge is built between Mukilteo on the mainland and the southern tip of Whidbey Island in the latter part of the projection period. Figure 7-20 portrays the future land use pattern (C_2) for the year 2020, and was developed based on a bridge being built after 1980 from the mainland to Whidbey Island.

The major concentration of intensive land use has been in the towns of Coupeville and Oak Harbor, plus in and around the Whidbey Naval Air Station. Both towns will continue to gain new population throughout the planning period, but a major share of new growth will be on, or near, the waterfront areas of the two Islands.

Without a bridge the population growth is expected to increase from 22,400 persons in 1967 to 49,500 persons by the year 2020. This will result in a need for only 3,100 additional acres of land being converted to intensive uses. If a bridge is built this will result in a population increase by 2020 to 115,000 persons and will require an additional 32,000 acres to be used for intensive land uses.

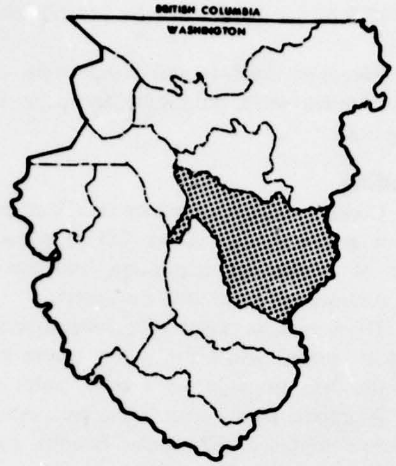
There will be a limited demand for industrial lands on the islands, although ample acreage is included in the land needs projected to accommodate any industrial need that may develop. A special effort must be put forth within the Islands to gain large acreages for recreation purposes, both public and private. An effort should be made by all levels of government, plus various private concerns that the full potential of recreation and "tourism" is realized within the Islands. With the growth projected for the Seattle–Everett–Tacoma complex, the recreation needs and potential of the Islands become even more critical.



WHIDBEY - CAMANO ISLANDS
GENERALIZED LAND USE MAP
Alternative C2 – 2020

FIGURE 7-20

SNOHOMISH BASIN



The Snohomish Basin is centrally located in the Puget Sound Area immediately northeast of the Seattle metropolitan complex. The Basin includes about half of Snohomish County and the northeast third of King County and contains a hydrologic area of 1,218,451 acres. Major tributary streams in the Snohomish Basin include the Skykomish River, which further divides into the Pilchuck, Sultan and the North and South Forks of the Skykomish; and the Snoqualmie River, which includes the Tolt River and the North, Middle and South Forks of the Snoqualmie.

Population

The population of the Basin in 1967 was 201,300. This population is primarily located in the Everett area and in a corridor between Everett and the King County line to the South. Projections show that the population will grow to 302,700 by 1980, 485,800 by 2000 and 780,300 persons by the year 2020. This growth will primarily take place adjacent to the existing areas of development in the western portions of the basin.

Land Use

The principal land use of the Snohomish Basin is forest and associated lands which cover 88% of the total Basin. The other two major uses, croplands and intensive land uses occupy 6% and 3% of the land respectively and are primarily located in the western portion of the Basin. Figure 7-21 the generalized land use map of the Snohomish Basin, portrays the land areas occupied by each of the major uses.

TABLE 7-25. Land use in Snohomish Basin (acres)[1]

Map No.	Watershed	Crop-land	Range-land	Total Forest[2]	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
8a	Snoqualmie River	20,150	420	406,867	4,287	5,087	8,875	445,686
8b-1	Skykomish River	5,806	755	411,039	6,682	2,334	6,812	433,428
8b-2	Sultan River	400		68,132	246	171	1,865	70,814
8b-4	Woods Creek	3,502		35,788	983	607	494	41,374
8-1	Pilchuck River	7,076	40	64,056	4,277	3,005	1,830	80,284
8-2	French Creek	8,328	50	7,437	1,411	649	190	18,065
8-3	Cathcart Area	1,911		6,419	401	166	349	9,246
8-4	Snohomish Estuary	18,029	1,114	15,809	6,066	9,204	1,997	52,219
8-5	Marshland Area	5,875		6,776	1,302	1,010	304	15,267
	Total Snohomish	71,077	2,379	1,022,323	25,655	22,233	22,716	1,166,383
0-26	Edmonds-Mukilteo			9,613	1,428	13,445	47	24,533
0-33	Tulalip-Warm Beach	675	45	22,763	2,277	677	1,098	27,535
	Total Pacific Drainages	675	45	32,376	3,705	14,122	1,145	52,068
	Snohomish Basin	71,752	2,424	1,054,699	29,360	36,355	23,861	1,218,451

[1] Unadjusted measurements, 1966, for Puget Sound Area Study.

[2] Figures include nonforested land commonly associated with forest areas.

AGRICULTURE

PRESENT STATUS AND POTENTIAL

The Snohomish Basin is located in southern Snohomish County and in northeastern King County. Approximately half of the Basin is located in each of the two counties.

The western part of the Basin has extensive alluvial flats and glacial terraces, graduating into a large, rugged mountainous section in the east. Of the total land area of 1,194,590 acres in the Basin, those lands outside the national forest boundaries have been mapped by a medium-intensity soil survey. Lands within the national forest have been mapped by a low-intensity soil survey suitable for reconnaissance use. Of the 660,800 acres of land mapped with the medium-intensity soil survey, approximately 379,000 acres are classified in Land Use Capability Classes II through VI.

These 379,000 acres of land have the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, IV are suited for either cropland or urban uses, and Class VI has potential for urban developments.

The Snohomish is one of the larger rivers in the Puget Sound Area. It drains an area of 1,823 square miles. The principal tributaries are the Snoqualmie River, located in King County and draining an important agricultural area, and the Skykomish River, located mainly in southern Snohomish County. Coastal waters, which outlet directly into Puget Sound, drain an area of 81 square miles.

The Snohomish Basin provides the third largest valley system in the Puget Sound Area. The system includes many flood and drainage problem areas which require corrective measures before their potential can be attained. The lower flood plain contains about 60,000 acres of level or gently undulating river bottom lands and tidelands. A large percentage of the Basin contains steep, mountainous valleys with turbulent streams. Below the juncture of the Snoqualmie and Skykomish Rivers, the valley drops almost to sea level and widens to a flat, fertile plain as much as three miles wide and 17 miles long.

Production

Forestry and farming remain the main users of land in the Snohomish Basin. Although considerable quantities of vegetables and berries are produced in the region, approximately three-fourths of the cropland is used to support the livestock industry. Total value of farm production is over $12 million annually.

Forestry supports numerous mills, including several lumber mills, pulp mills, and paper manufacturing mills.

Flooding

Climatic conditions induce two flood-producing seasons annually; one in the fall or winter as the result of excessive precipitation, and the other in early summer as the result of snowmelt.

Discharges in excess of channel capacity cause water to spread across the valley, where it remains until the river drops. In many areas, water is trapped by topographic detail until it can seep into the soil. Excessive rainfall causes similar flooding conditions, as well as swamping of the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV. Principles and conditions discussed therein apply to the Snohomish Basin and need not be repeated here.

Watersheds

Eleven watershed areas requiring solutions to problems, or development to achieve the potential productivity of the Basin, are shown on the Land Use Map (Figure 7-21) and on the Land Capability Map (Figure 7-22).

The Snoqualmie River watershed (8a) is almost 92 percent forested. A large part of the forest, approximately 40 percent, lies within the Snoqualmie National Forest. Cropland in this watershed, although not as important as forestry, makes up more than 25 percent of all cropland in the entire Basin.

Skykomish River watershed (8b-1) is dominated by forest, being over 70 percent within the Snoqualmie National Forest. Farming is of slight importance. Future potential is largely for forest use.

Sultan River watershed (8b-2) is tributary to the Skykomish River and its characteristics are similar.

Woods Creek watershed (8b-4) is tributary to the Skykomish River and in many respects its characteristics are similar. Cropland is more important is this watershed, however, and with development, it can become even more important.

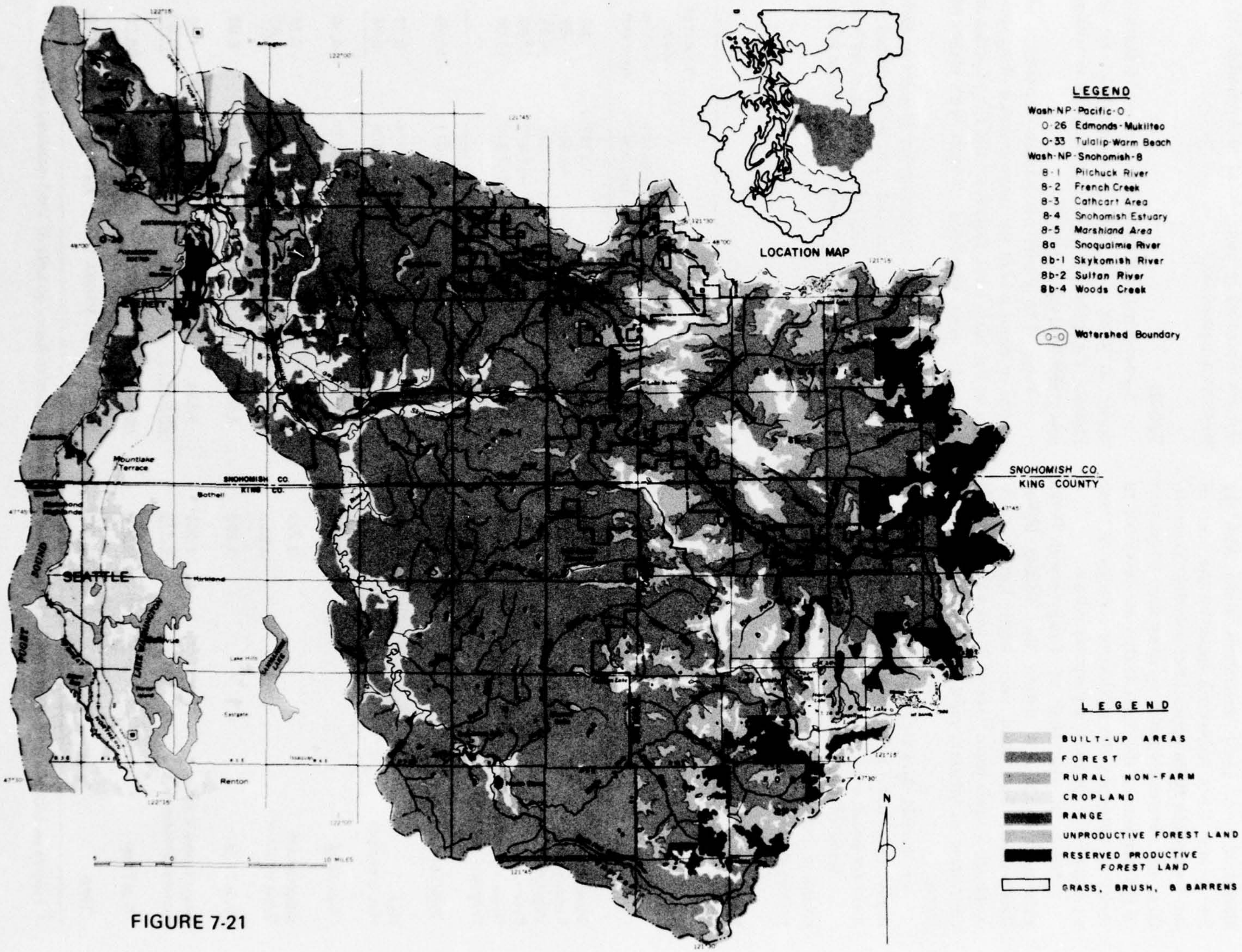


FIGURE 7-21

SNOHOMISH BASIN
GENERALIZED LAND USE MAP

The Pilchuck River (8-1); French Creek (8-2); Cathcart Area (8-3); Snohomish Estuary (8-4); and Marshland Area (8-5) watersheds along with the Snoqualmie River watershed, make up the heart of the Snohomish Basin agricultural industry. Together, these six watersheds make up more than 85 percent of the cropland in the Basin. If they are developed to their full potential, the productive capacity of these watersheds for agricultural purposes is high.

Much of the land of Tulalip-Warm Beach watershed (0-33) lies within the Tulalip Indian Reservation. The land has been logged once. Although a small percentage of it has been placed in cultivation or pasture, most of the land remains in forest.

Edmonds–Mukilteo watershed (0-26) has little, if any, agricultural land. Its potential lies in development for urban use.

Many of the farmlands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions are summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the Snohomish Basin is shown in Table 7-25. The following tables are to indicate the potential development possible within acceptable land use standards.

Table 7-26 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-27 shows the number of acres in each capability class, subclass, and unit, by watershed, in the Snohomish Basin. This table can be used with the description of capability units to estimate the potential for development.

TABLE 7-26. Distribution and value of production by crops in Snohomish Basin

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	549	832	1.16	40,127	.52
Field crops	110	166	.23	49,569	.64
Vegetables	4,032	6,111	8.52	1,311,475	16.87
Berries	631	956	1.33	983,970	12.66
Nursery products	325	493	.69	859,930	11.06
Cropland not used	2,393	3,627	5.05	--	--
Sub-Total	8,040	12,185	16.98	3,245,071	41.75
Hay	9,549	14,472	20.17	678,324	8.72
Hay aftermath	--	--	--	430,506	5.54
Sub-Total	9,549	14,472	20.17	1,108,830	14.26
Silage (grass)	3,223	4,885	6.81	323,650	4.16
Grass aftermath	--	--	--	145,610	1.87
Sub-Total	3,223	4,885	6.81	469,260	6.03
Silage (corn) fodder	1,052	1,594	2.22	105,611	1.36
Pasture (cropland)	25,479	38,616	53.82	2,845,829	33.60
Sub-Total	39,303	59,567	83.02	4,529,530	58.25
Total	47,343	71,752	100.00	7,774,601	100.00

[1] *Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.*

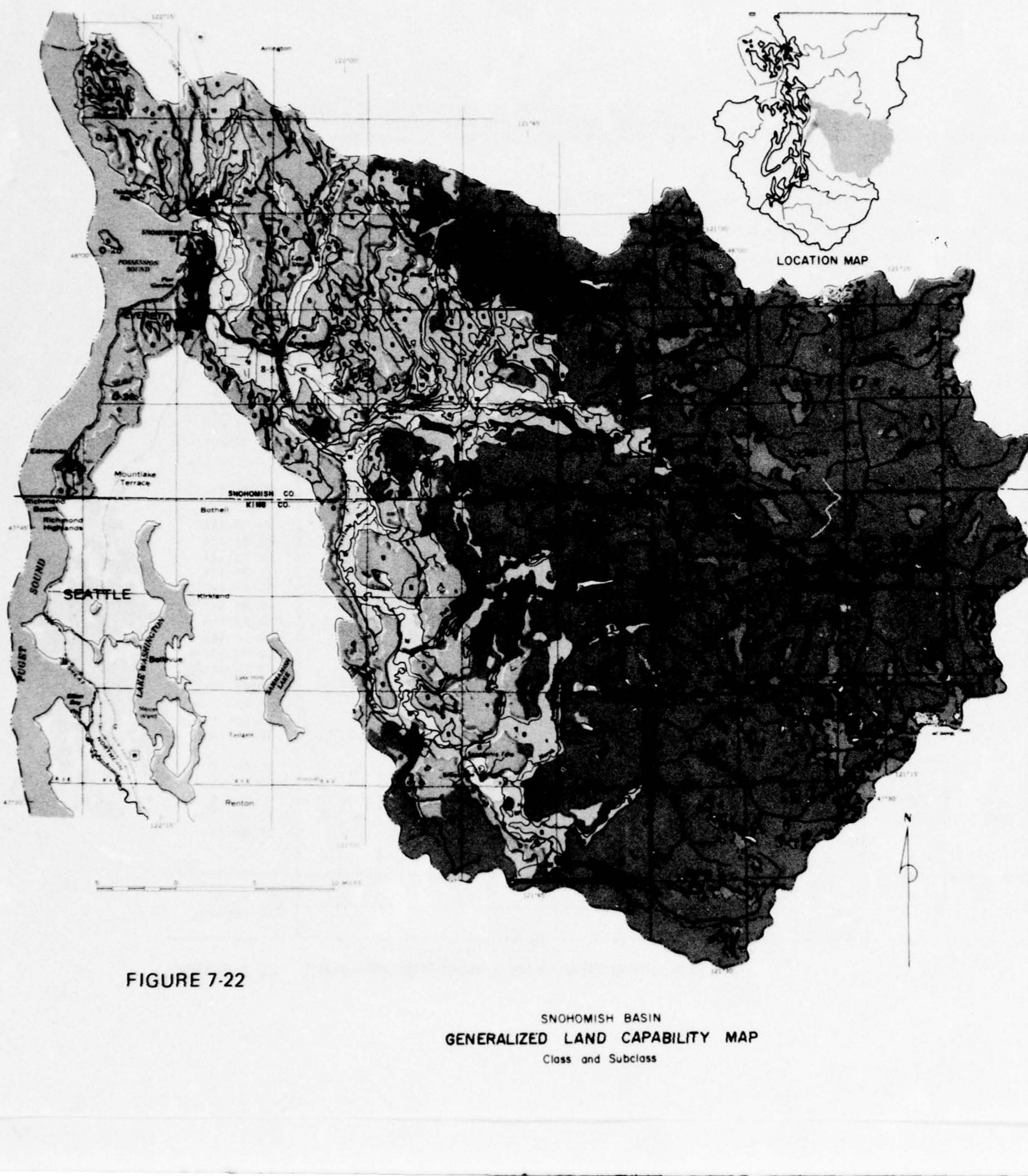


FIGURE 7-22

SNOHOMISH BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

TABLE 7-27. Land capability units in Snohomish Basin (in acres)[1]

Sheet 1 of 2

Capability units 2/	WATERSHEDS										
	8a	8b-1	8b-2	8b-4	8-1	8-2	8-3	8-4	8-5	0-26	0-33	Total
II ws 02	821			298	105	455						1,679
II ws 03	8,894	2,816	502	663	278	435			299			13,887
II ws 04	5,880	1,041		20	909	2,318	766	7,958	4,136		202	23,230
II ws 06	2,907	399	440	604	1,741	2,095	135	2,391	761	341	731	12,545
II so 01	286											286
II TOTAL	18,788	4,256	942	1,585	3,033	5,303	901	10,349	5,196	341	933	51,627
III ew 01	2,500	3,556	390	3,343	775	607	140	861		30	350	12,552
III es 02				328	230	60	310	50	449			1,427
III ws 01	3,704	2,071	180		1,062	376	280	685	898	40		9,296
III ws 05	484											484
III ws 08	10	110	5	412	227	172	55	4,951	15	155	327	6,439
III ws 09	423	307	40	1,018	1,749	201	293	3,821	212	359	210	8,633
III ws 10		50		180	298	334	155	540		76	470	2,103
III ws 12	35											35
III so 01	150	1,023	30	70	2,030	854	20	30				4,207
III so 08	247											247
III sw 09		16		297	685			60		35		1,093
III TOTAL	7,553	7,133	645	5,648	7,056	2,604	1,253	10,998	1,574	695	1,357	46,516
IV ew 12	130											130
IV ew 22	39,158	1,020	568	7,676	22,237	2,804	2,586	14,838	5,263	11,945	17,190	125,285
IV es 08	4,626											4,626
IV es 09	320											320
IV ws 05	169	10			23	318		95	25			640
IV ws 06	872	160		160	359	188	20	725	127	48	70	2,729
IV ws 10	225											225
IV so 01	8,608	1,404	187	1,271	2,800	919	435	440	61	350	195	16,670
IV so 10											19	19
IV se 05	746											746
IV se 13	1,466											1,466
IV sw 09					643					50	130	823
IV TOTAL	56,320	2,594	755	9,107	26,062	4,229	3,041	16,098	5,476	12,393	17,604	153,679
II-IV TOTAL	82,661	13,983	2,342	16,340	36,151	12,136	5,195	37,445	12,246	13,429	19,894	251,822

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include lands within national forest boundaries.
2/ See Exhibit 1 for description of capability units.

TABLE 7-27. Land capability units in Snohomish Basin (acres)[1] (continued)

Sheet 2 of 2

Capability units 2/	WATERSHEDS 8a	8b-1	8b-2	8b-4	8-1	8-2	8-3	8-4	8-5	0-26	0-33	Total
V ws 21	911											911
V TOTAL	911											911
VI ew 21	8,707	2,130	338	2,639	3,073	651	718	1,815	282	2,414	1,836	24,603
VI ew 28	1,963											1,963
VI es 19	2,112	1,056	2,695	5,458	3,828	2,169	277	400	567	1,525	319	20,406
VI es 22	1,183											1,183
VI ws 19	1,878	1,958			35	25	65	65	70			4,096
VI so 01	4,075											4,075
VI so 12	1,125											1,125
VI so 18	962	6,752	3,543	4,155	2,998	624	130	7,115	150	664	752	27,845
VI se 13	14,425											14,425
VI se 17	3,895	360	2,434	3,947	6,338	845	1,202	1,531	1,048	2,084	2,823	26,507
VI se 21	85											85
VI TOTAL	40,410	12,256	9,010	16,199	16,272	4,314	2,392	10,926	2,117	6,687	5,730	126,313
VII es 29	50	1,537		50	15							1,652
VII es 36	147,506	55,244	34,319	6,966	19,470	1,382	1,200	858	557	4,002	565	272,069
VII ws 20		502										502
VII so 23		1,205	65	435	725							2,430
VII TOTAL	147,556	58,488	34,384	7,451	20,210	1,382	1,200	858	557	4,002	565	276,653
VIII ew 39								10		209	70	289
VIII ws 00	860	1,041			250	35	105		20			2,311
VIII ws 23	175							583		100		858
VIII ws 24	664	15	28	73	160	8	5	110	23	44	178	1,308
VIII so 00								290		15		305
VIII TOTAL	1,699	1,056	28	73	410	43	110	993	43	368	248	5,071
V-VIII TOTAL	190,576	71,800	43,422	23,723	36,892	5,739	3,702	12,777	2,717	11,057	6,543	408,948
II-VIII TOTAL	273,237	85,783	45,764	40,063	73,043	17,875	8,897	50,222	14,963	24,486	26,437	660,770

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include lands within national forest boundaries.

2/ See Exhibit 1 for description of capability units.

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the Snohomish Basin will increase from 201,300 persons in 1967 to about 780,300 by 2020, according to Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 65,715 acres presently in intensive and rural nonagricultural use could provide ample acreage for new intensive development to the year 1980 without encroachment onto the croplands of the Basin. For the time period 1980-2000, approximately 15,250 acres must be added from some other land use to keep the density per acre at six. For the time period 2000-2020, an additional 50,000 acres will be needed.

Cropland Needs

The Snohomish Basin presently has 71,752 acres of cropland. The Basin is expected to lose some cropland to other uses so that cropland will total about 60,000 acres by 2020. The percent increases needed, by crops, for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Data in Table 7-28 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Snohomish Basin is summarized under the topic "Program Implementation" immediately following "Forestry." A more complete description is found in Appendix XIV, Watershed Managment.

TABLE 7-28. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	57,532	57,532	57,532
Watershed protection and rehabilitation[2]	acre	68,424	66,424	62,424
Drainage improvement	acre	25,718	42,863	57,150
Irrigation development[3]	acre	24,000	30,000	48,000
Water for irrigation[4]	ac.ft.	46,080	57,600	92,160

[1] A total of 93,449 acres in the Snohomish Basin are subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated hare.

[2] Includes 2,424 acres of rangeland.

[3] According to Appendix VII, Irrigation, there were 12,800 acres (using 24,576 acre-feet of water) irrigated in 1966. Irrigation Appendix projections show 14,800 acres irrigated by 1980, 18,700 acres by 2000, and 20,000 acres by 2020.

[4] Based on gross diversion requirements of 1.92 acre-feet per acre, estimated by Irrigation Committee in Appendix VII, Irrigation.

FORESTS

PRESENT STATUS

The Snohomish Basin is the third largest Basin in the Puget Sound Area in terms of hydrologic area, total forest area, and commercial forest area. This Basin is well covered with forests that reach from the mountainous areas into the lower lands occupied by farms, ranches, and communities. 1,055,000[1] acres, or 82.2% of the hydrologic area, is classified as forest land. Reserved lands in the Snohomish Basin total 83,000 acres, most of which are within the Alpine Lakes Primitive Area (Table 7-29).

[1] Does not include nonforested lands commonly associated with forest areas.

The available timber land is classified into the following resource zones:

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	161,310	17.8
Principal Forest	553,070	61.2
Upper Forest	149,220	16.5
Subalpine	40,440	4.5
Total available	904,040	100.0

TABLE 7-29. Snohomish Basin-Area of forest land, in acres, by ownership and type

Cover Type of Land Class	Available								
	National Forest	Other Federal	State & County	Munici-cipal	Indian	Private	Total Avail-able	Unavail-able	Total Avail. & Unavail.
Douglas Fir									
seedlings and saplings	4,370	--	1,780	190	180	8,750	15,270	130	15,400
poletimber	7,110	--	10,050	7,380	1,010	35,860	61,410	230	61,640
small young growth sawtimber	5,370	--	9,560	7,050	510	52,180	74,670	5,330	80,000
old growth and large young growth sawtimber	18,910	--	2,290	520	--	10,760	32,480	4,090	36,570
True fir—mountain hemlock									
seedlings and saplings	3,280	--	--	--	--	340	3,620	1,490	5,110
poletimber	3,670	--	--	--	--	2,950	6,620	1,080	7,700
small sawtimber	18,020	--	3,110	--	--	970	22,100	8,760	30,860
large sawtimber	56,300	--	6,210	26,960	--	26,590	116,060	20,740	136,800
Western hemlock									
seedlings and saplings	5,950	10	9,580	2,940	--	22,360	40,840	290	41,130
poletimber	1,220	--	13,230	1,960	--	21,720	38,130	560	38,690
small sawtimber	5,450	--	3,990	720	--	13,540	23,700	1,120	24,820
large sawtimber	43,770	--	23,360	--	--	46,200	113,330	5,340	118,670
Western redcedar									
poletimber	290	--	--	--	--	1,440	1,730	--	1,730
small sawtimber	2,270	--	--	--	110	1,360	3,740	570	4,310
large sawtimber	7,870	--	1,920	--	--	8,030	17,820	1,090	18,910
Lodgepole pine									
seedlings and saplings	--	--	--	--	--	30	30	--	30
Sitka-Englemann spruce									
poletimber	--	--	--	--	--	610	610	--	610
small sawtimber	--	--	--	--	--	210	210	--	210
Western white pine,									
poletimber	--	--	--	--	--	80	80	--	80
small sawtimber	290	--	--	--	30	--	320	--	320
large sawtimber	290	--	--	--	--	--	290	--	290
SUBTOTAL, softwoods	184,430	10	85,080	47,720	1,840	253,980	573,060	50,820	623,880
Hardwoods									
seedlings and saplings	1,160	--	2,310	390	600	6,330	10,790	20	10,810
poletimber	4,520	40	11,170	330	4,520	83,550	104,130	180	104,310
small sawtimber	2,680	10	8,430	2,020	1,630	69,400	84,170	1,170	85,340
large sawtimber	290	--	--	--	90	2,830	3,210	--	3,210
SUBTOTAL, hardwoods	8,650	50	21,910	2,740	6,840	162,110	202,300	1,370	203,670
Nonstocked									
cutover	2,730	--	1,540	--	--	2,440	6,710	10	6,720
deforested by fire	1,940	--	50	--	--	--	1,990	890	2,880
SUBTOTAL, nonstocked	4,670	--	1,590	--	--	2,440	8,700	900	9,600
TOTAL, productive land	197,750	60	108,580	50,460	8,680	418,530	784,060	53,090	837,150
Subalpine	33,830	--	5,750	--	--	860	40,440	8,020	48,460
Noncommercial rocky	67,760	490	7,440	--	--	3,850	79,540	22,030	101,570
Noncommercial, rocky									
TOTAL, unproductive land	101,590	490	13,190	--	--	4,710	119,980	30,050	150,030
TOTAL, all forested land	299,340	550	121,770	50,460	8,680	423,240	904,040	83,140	987,180

The Snohomish Basin contains 784,000 acres of commercial forest land capable of producing continuous crops of industrial wood. These lands support a sawtimber inventory of 19.2 billion board feet, International ¼-inch Rule (Table 7-30). These figures represent 15.9% of the commercial forest land and 18.7% of the sawtimber inventory of the Puget Sound Area. Private lands, located in the western half of the Basin, consist of 418,500 acres, or 53% of the commercial forest area. Large corporate holdings include 259,300 acres, medium sized private holdings 1,700 acres, and small private ownerships 157,500 acres. Public forest lands are nearly all located in the eastern half of the Basin and total some 365,500 acres. Ownership of the public land is 54% National Forest, 30% State and County, 14% municipal and 2% other miscellaneous public.

The Snohomish Basin is well served by a variety of forest products manufacturing plants, particularly in the Everett area. Of the 34 wood using industrial

TABLE 7-30. Snohomish Basin—Volume of sawtimber and growing stock, by ownership, on productive forest land

	Available								Total
Species or Group	National Forest	Other Federal	State & County	Municipal	Indian	Private	Total available	Unavailable	Total Available & Unavailable
Sawtimber—Thousand board feet, International ¼-inch Rule									
Douglas fir									
small sawtimber	91,330	--	155,720	118,580	7,520	779,110	1,152,310	64,490	1,216,800
large sawtimber	1,045,600	--	135,010	39,190	1,610	602,800	1,824,210	167,110	1,991,320
True fir—mountain hemlock									
small sawtimber	318,070	--	45,760	--	--	20,580	384,410	142,320	526,730
large sawtimber	3,468,600	--	390,910	1,460,410	--	1,581,690	6,901,610	1,197,550	8,099,160
Western hemlock									
small sawtimber	86,330	--	71,850	16,380	--	235,510	410,070	20,290	430,360
large sawtimber	2,298,910	10	1,241,460	4,370	--	2,378,900	5,923,650	296,390	6,220,040
Western redcedar									
small sawtimber	46,960	--	--	--	2,530	23,310	72,800	9,840	82,640
large sawtimber	704,610	--	136,930	--	--	492,580	1,334,120	87,780	1,421,900
Other softwood species									
small sawtimber	4,990	--	--	--	500	4,650	10,140	--	10,140
large sawtimber	15,710	--	--	--	--	1,210	16,920	--	16,920
SUBTOTAL, softwoods	8,081,160	10	2,177,640	1,638,930	12,160	6,120,340	18,030,240	1,985,770	20,016,010
Hardwoods									
small sawtimber	31,610	110	97,770	19,710	21,430	756,880	927,510	11,270	938,780
large sawtimber	11,370	30	11,970	410	8,880	168,130	200,790	200	200,990
SUBTOTAL, hardwoods	42,980	140	109,740	20,120	30,310	925,010	1,128,300	11,470	1,139,770
TOTAL SAWTIMBER, all species	8,124,140	150	2,287,380	1,659,050	42,470	7,045,350	19,158,540	1,997,240	21,155,780
Growing Stock—Million cubic feet									
Douglas fir	207.1	--	53.0	28.7	1.7	251.7	542.2	42.2	584.4
True fir—mountain hemlock	684.9	--	79.0	264.2	--	289.8	1,317.9	242.4	1,560.3
Western hemlock	464.8	--	255.9	4.0	--	509.4	1,234.1	61.7	1,295.8
Other softwood species	305.8	--	54.2	--	1.2	206.6	567.8	38.6	606.4
SUBTOTAL, softwoods	1,662.6	0.0	442.1	296.9	2.9	1,257.5	3,662.0	384.9	4,046.9
Hardwoods	17.0	0.1	43.4	8.0	12.0	365.6	446.1	4.5	450.6
TOTAL GROWING STOCK all species	1,679.6	0.1	485.5	304.9	14.9	1,623.1	4,108.1	389.4	4,497.5

plants in the Basin, 12 are located in Everett. These 12 require 928,000 board feet of raw material per day on the average. The remaining 22 plants are located in Shohomish, Snoqualmie Falls, Marysville, Granite Falls, Preston, North Bend, Carnation, and Skykomish. Several other towns have small plants operating on an intermittent basis. The 34 plants range from sawmills, with all their allied products, through pulp and paper mills and plywood plants to smaller facilities producing specialty products such asmoulding, fencing, and shakes and shingles.

Problems in Snohomish Basin are typical of other Basins. Smaller ownerships need better forest land management and more readily available manufacturing facilities within reasonable hauling distance. All ownerships have problems of access to the public road system. Unstable soils at higher elevations need expert planning and treatment during forest harvesting and road construction. Fire prevention needs to be improved in the middle and higher elevations.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

No determination of the demand for wood products is made specifically for the Snohomish Basin. The nature of the forest products industries, particularly the relative ease of log transportation between the basins, would make such a determination rather meaningless. In addition, a specific figure would imply that a production goal was established for the basin, which is not the case. Production goals are established for the Puget Sound Area as a whole, with the assumption that considerable shifts in production between the basins will occur, depending upon the actual pattern of industrial and land use development.

For sake of basin comparison, however, there is some value in showing the percentage of demand that may be supplied by the Snohomish Basin in the future. In 2020, the Snohomish Basin is expected to contain about 17% of the commercial forest land in the Puget Sound Area. The percentage in earlier periods is slightly lower. It is therefore assumed that the basin will supply approximately 17% of the total wood products demand in the future.

The effect of competing uses for forest lands is discussed in detail in the section covering the Puget Sound Area. The estimated diversion of forest land from these causes in the Snohomish Basin is shown below:

Type of Land Diversion	Acres Diverted (2020)
Parks, Wilderness, Campgrounds, or other Recreation Use	43,720 [1]
Roads and Highways	20,810
Urban-Industrial Development	49.490
Reservoirs, Powerlines, and other miscellaneous conversion	2,500
Private Land Use Reservations	29,240
Total	58,320

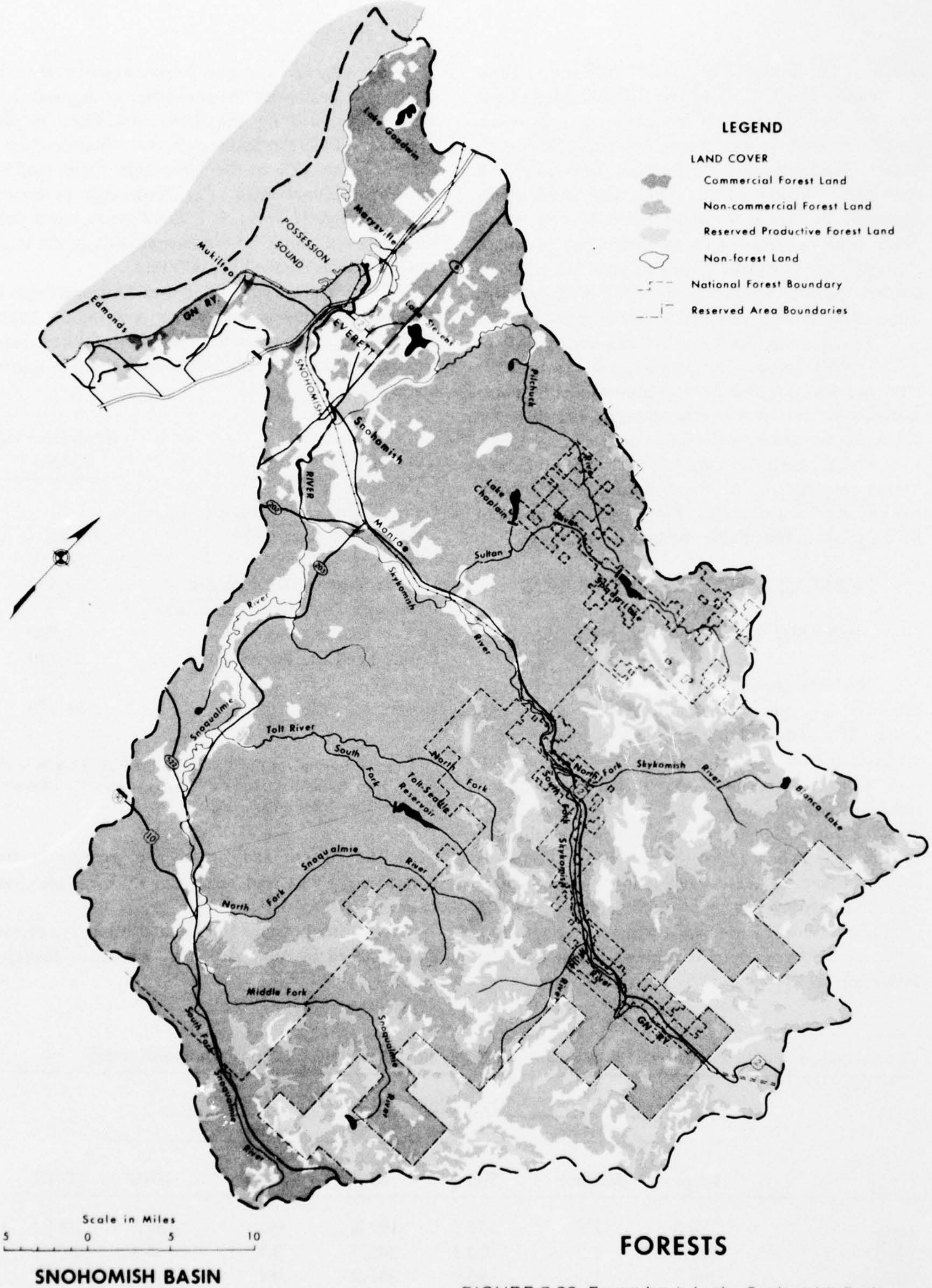
[1] This is a plus figure—the revision of the Alpine Lakes limited area to wilderness status (S.B. 1321) actually increases the available commercial area.

The current and prospective changes in the commercial forest land base from all causes are given below.

Specific measures for soil and water protection are discussed in Appendix XIV, Watershed Management.

Current and projected commercial forest area in the Snohomish Basin 1965-2020 (in thousand acres)

	Ownership						
	Private			Public			
Period	Large	Medium	Small	NF	Other Federal	Other	Total
1965	259.3	1.7	157.5	197.8	0.1	167.7	784.1
1980	261.5	1.7	134.1	245.7	0.1	165.4	808.5
2000	268.7	1.7	93.9	241.3	0.1	163.0	768.7
2020	269.7	1.6	53.2	240.0	0.1	160.3	724.9



FORESTS

FIGURE 7-23. Forest lands in the Snohomish Basin

PROGRAM IMPLEMENTATION AGRICULTURE AND FORESTS

The plan to accomplish agricultural and forestry development required in the Snohomish Basin, as shown by the preceding pages, will be multipurpose in nature. Through the program, floodwater prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development, will be established as necessary in order to meet the needs of an increasing population. Other measures provide for water quality and quantity control, recreation, and fish and wildlife development.

This plan contains programs and projects to accomplish specific objectives of conservation and development. It provides for the full development of lands presently used for farming. Most of this land will continue to be farmed but approximately 6,000 acres of bench terrace farmland will be lost to other uses by 2020.

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000); and (c) distant future (2000-2020).

Program measures refer to onsite practices which take advantage of development made possible by the strucutral works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage developments, forest management practices, and irrigation developments. Total cost of the program for the early action period is $49,982,000.

There are two early action projects described in Watershed Management, Appendix XIV. Primary agricultural benefits from these projects are prevention of flooding and drainage improvement. The two projects are expected to cost $142,000 annually, and to result in annual benefits of $396,800 for a benefit-to-cost ratio of 2.8 to 1.

Seven projects with an installation cost of $12,240,000 are proposed for after 1980 and one project with a cost of $100,000 will be installed after the year 2000. Program costs are expected to be $75,705,000 for the period after 1980 and $77,018,000 for the period after 2000. Total cost of the plan is expected to be $217,548,000.

A summary of the early action projects is given in Table 2-21 of the Puget Sound Area section on Agriculture. A presentation of the proposed plan, including Agriculture, can be found in Appendix XIV, Watershed Management, Snohomish Basin section.

MINERALS

The locations of the known mineral deposits in the Basin are shown in Figure 7-24. The open circles on the maps indicate properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

The Snohomish Basin is one of the most important mineral producing regions of the Puget Sound Area. Its mineral resources are varied, and it has a long history of production. Mineral commodities that have been produced are sand and gravel, limestone, clay, basalt, sandstone, granite, mineral water, antimony, arsenic, copper, gold, silver, and iron. Other mineral deposits that have been found in the area are coal, diatomite, asbestos, nickel, zinc, lead, and molybdenum.

Limestone

Limestone occurs as lenses and beds in argillite and volcanic rocks of Paleozoic age. The deposits occur near Granite Falls on Pilchuck Creek, near Gold Bar and Grotto on the South Fork of the Snoqualmie River.

Most of the limestone produced has been used to make portland cement; the remainder was used for agricultural purposes. Production first began in 1928 at the Grotto plant of Northwest Portland Cement Co. (now Ideal Cement Co.) and has been continuous ever since. Total production of limestone to date (1966) is estimated at about 2 million tons.

Reserves are estimated to be over 7.5 million tons. A summary of the deposits follows: five deposits with less than 10,000 tons each or whose size in unknown, six deposits with more than 10,000 tons but less than 1 million tons each, and one deposit that contains more than 1 million tons.

Sand and Gravel

The best sand and gravel deposits are found in the glacial outwash material that blankets the western part of the area. Because the rapidly expanding urbanization of the western border of the Basin is eliminating from use the gravel deposits there, almost the only gravels available for use are those farther to the east on the outwash plain. River-bar gravel along the Skykomish and Snoqualmie Rivers also is suitable for aggregate use.

The exact number of sand and gravel pits that have produced aggregate or fill material is not known, but the number probably exceeds 100. Many of them have been covered or rendered unusable by eastward urban expansion of the communities bordering Puget Sound.

Clay

Clay deposits are relatively widespread, especially in the western part of the area. The clay deposits are both glacial and alluvial in origin. At one time or another, eight pits have produced clay for brick, tile, pottery, and as an ingredient in cement. Presently (1966), two pits are in operation, and these seem to adequately fill the needs of the area for their particular product or use. One pit, which is in south Everett, supplies clay for red-burning ware. The other pit, at Grotto, produces shale which is used as an ingredient in making portland cement.

No estimate of clay reserves is available, but the reserves are sufficiently large to meet projected future demands, provided the clay deposits are not overrun by urban expansion. Complete production figures are not available, but from 1944 to 1963, approximately 280,000 tons of clay and shale was mined.

Stone Other Than Limestone

Five basalt, one sandstone, and six granite quarries are in the Snohomish Basin. Six of these quarries—two granite and four basalt—are currently (1966) operating. The basalt quarries produce rubble, landscape rock, riprap, and crushed rock. One granite quarry, at Baring, produces material that is crushed and used for poultry grit. The other granite quarry produces rubble and landscape rock.

No reserve figures are available, but there appears to be an adequate amount of material available to meet needs for several years to come. However, the adequacy of the reserves is difficult to predict, because mining operations in the western part of the Basin are being curtailed more and more by zoning restrictions. Production figures are not available for publication.

Mineral Water

Two mineral springs have been developed for commercial use, but only Garland Mineral Springs (Fig. 7-24, No. 36) is still used in conjunction with a resort. The temperatures of the four springs at Garland range from 50 to 84 F. Mineral contents vary, but they are generally low in sulfur and iron. Scenic Hot Springs (Fig. 7-24, No. 41) was once operated as a resort, but now the waters are not used. An attempt was made in the early days to develop Goldmeyer Hot Springs as a hotel resort, but it failed.

Other mineral springs are the Skykomish Mineral Springs (not shown on map) and Money Creek soda springs.

Coal

Two coal seams were opened along Raging River between 1886 and 1888. Considerable development work was done on the property, and about 25,000 tons of coal was taken out. About 23 feet of carbonaceous material containing approximately 7 to 12 feet of coal in two main beds make up the coal measures. Reserves amount to about 14 million tons. The coal occurs in the Puget Group, but its stratigraphic position in the unit is not known.

Peat

There are probably over a hundred peat deposits, the largest of which covers 1,975 acres. Twenty-six bogs have been investigated in detail, and there are seven bogs that currently have commercial peat operations on them. Peat bogs cover a total of 5,780 acres. Sphagnum peat occurs in 14 of the area's bogs. Production figures for the drainage system are not available for publication. Reserves are probably adequate for many years' supply.

Diatomite

No diatomite has been produced, and little information is available on the one known deposit. Available information indicates that it is too small to be of much interest.

Asbestos

One asbestos property is known. The asbestos is a crossfiber variety in which the fibers are ¼ inch long. The deposit is in a peridotite country rock. The property has no record of production.

MINERAL PROPERTIES IN SNOHOMISH BASIN*

Explanation for Figure 7-24

Metallic Minerals

(with production or reserves data where available)

Antimony (3 properties)
- 78 - Grand Central
- 76 - Great Republic

Arsenic (1 property)
- 66 - Reiter (prod.–22 tons)

Copper (91 properties)
- 61 - Broken Ridge
- 71 - Buckeye
- 73 - Climax
- 65 - Charlotte (prod.–2 carloads)
- 67 - Copper Bell
- 68 - Copper King
- 87 - Dutch Miller
- 64 - Ethel (prod.–400 tons)
- 53 - Florence Rae (prod.–606 tons
- 52 - Iowa (prod.–200 tons)
- 60 - Kromona (prod. more than $13,000)
- 70 - Lake Serene (prod. more than 4 carloads)
- 51 - Mackinaw
- 86 - Middle Fork (reserves more than 100 tons)
- 56 - New York-Seattle
- 85 - Quartz Creek (reserves–4.5 million tons)
- 80 - Snoqualmie
- 54 - Sultan King
- 58 - Sunrise (reserves–4.5 million tons)
- 69 - Sunset (prod.–13 million lbs., cu.; reserves–500,000 tons)
- 78 - Una

Gold (138 properties)
- 75 - Apex (prod.–$300,000)
- 59 - Blue Bird
- 81 - Coney Basin (prod. more than 40 tons)
- 88 - Carmack (prod.–20 tons)
- 74 - Damon and Pythias (prod.–22 tons)
- 55 - Good Hope (prod. more than one carload)
- 57 - Horseshoe Bend Placer
- 62 - Index Gold Mines, Inc.
- 59A - Last Change
- 79 - Lennox

Iron (8 properties)
- 72 - Anderson
- 55A - Lockwood Pyrite (reserves–3.5 million tons)

Lead (18 properties)

Molybdenum (3 properties)

Nickel (2 properties)

Silver (10 properties)
- 84 - Aces Up
- 83 - Cleopatra
- 77 - Seattle-Cascade

Zinc (3 properties)

Nonmetallic Minerals

(with reserves data where available)

Asbestos (1 property)

Coal (reserves–14 million tons)

Common clay (8 properties)
- 32 - Dregon Flower-Pot Co.
- 34 - Everett Brick Yard
- 40 - Grotto
- 35 - Lowell Brick & Tile Co.
- 38 - Meadowdale Pottery
- 39 - Monroe
- 33 - Schaffer Brick Yard
- 37 - Snohomish

Diatomite (1 property)

Mineral water (5 springs)
- 36 - Garland Hot Springs
- 41 - Scenic Hot Springs

Stone Deposits

Limestone

Reserves
- Less than 10,000 tons (5 properties)
- 10,000 to 1 million tons (6 properties)
- More than 1 million tons (1 property)

Basalt (5 properties)

Granite (6 properties)

Sandstone (1 property)

*Some properties not plotted on map because of poor description of location and/or lack of space.

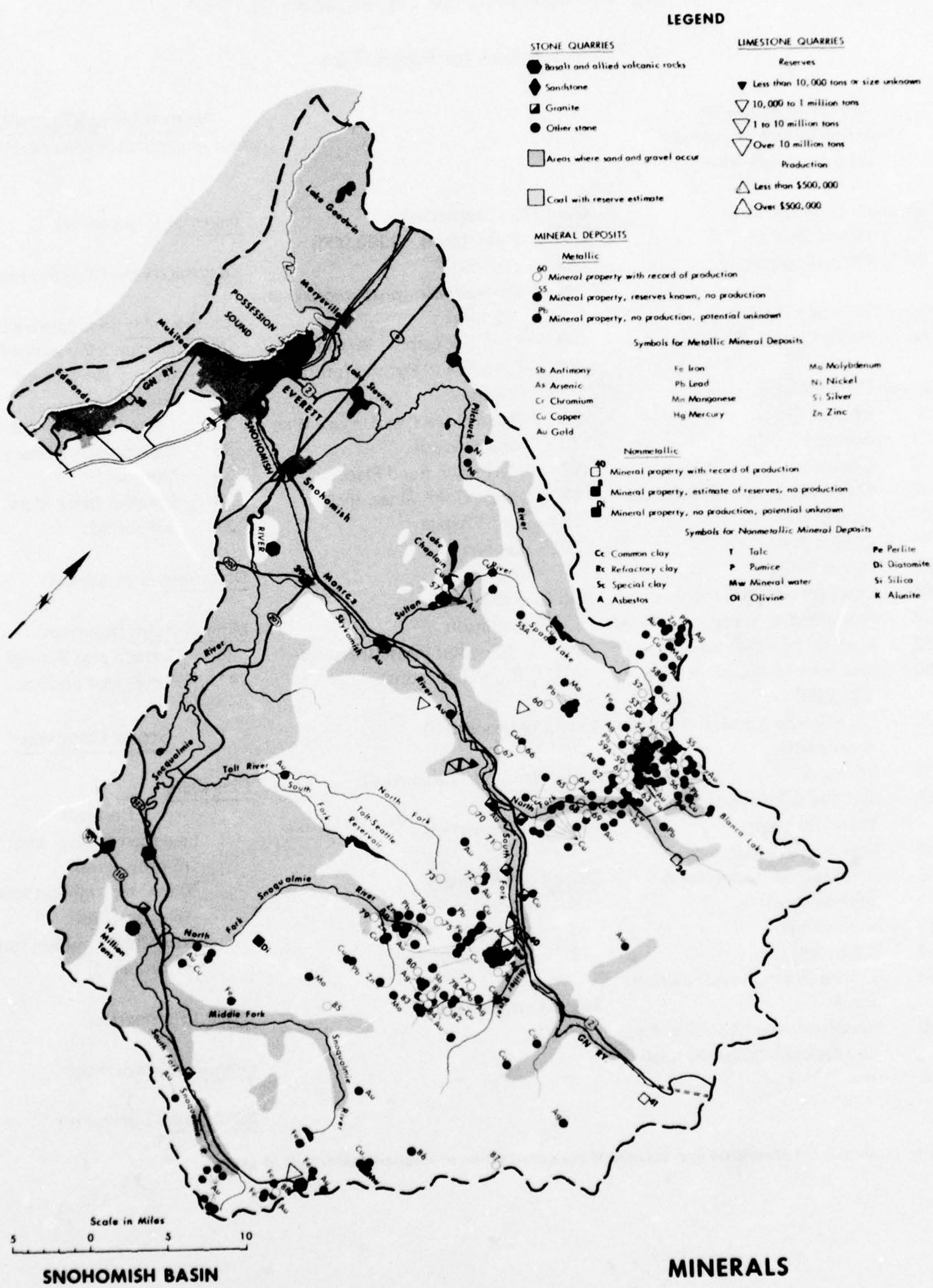


FIGURE 7-24. Mineral resources in the Snohomish Basin

Antimony

Of three antimony properties, two are reported to have had production. Antimony was discovered at the Great Republic mine during 1892, and a small amount of ore was mined there between 1901 and 1905. Production is reported for the years 1938 through 1941, but no statistics are available. The ore deposit is in a flat-lying mineralized fault in andesite, and the ore mineral is stibnite. Values of gold and silver have been reported from the property also.

An unknown amount of ore was produced from the Grand Central mine in 1908. Stibnite is in narrow veinlets of quartz, calcite, and pyrite along a 40-foot-wide zone in andesite.

Arsenic

Washington was the first State in the United States to produce white arsenic. The smelter was located at Everett, and for 2 years, part of the ore came from the Reiter mine (Fig. 7-24, No. 66). Production from the Reiter amounted to 22 tons of arsenic, and the property produced for only 2 years. The ore deposit consisted of 2- to 12-inch fracture fillings in granodiorite.

Copper

At least 91 copper properties are known, 19 of which have reported production or have made test shipments.

Shipments from the Charlotte mine (Fig. 7-24, No. 65) have been two carloads of high-grade ore. The mineral deposit consists of small lenses of ore along a shear zone in granodiorite. The mineralized zone is 20 feet in diameter and has a maximum width of 4 feet; its length is unknown.

About 400 tons of ore have been shipped from the Ethel mine (Fig. 7-24, No. 64). The ore deposit is along a shear zone in granodiorite. The width of the zone varies from a few inches to 27 feet.

The Florence Rae mine (Fig. 7-24, No. 53) produced 101 tons of ore during 1918 and 1919, and 505 tons of ore from 1937 to 1941. The 505 tons averages 12.4 percent copper, 0.01 ounce of gold per ton, 2.36 ounces of silver per ton, 0.8 percent zinc, and 0.07 percent nickel. The ore deposit consists of four principal vein systems in metamorphic rocks and quartz diorite.

Production from the Iowa mine (Fig. 7-24, No. 52) amounted to 104 tons prior to 1937 and 96 tons from 1937 to 1941. The ore shipped prior to 1937 assayed 10 percent copper, 0.233 ounce of gold per ton, and 3.23 ounces of silver per ton. Mineralization is along fracture zones in metamorphic rocks and diorite. Zones vary in width from a few inches to 48 inches.

The Kromona mine (Fig. 7-24, No. 60) is in a shear zone that crosses the contact of quartz diorite with older metamorphic rocks. In 1954, 102 tons of concentrates shipped from the property gave a net return of $13,191. Concentrates were also shipped in 1955, 1958, 1959, 1960, 1961, and 1962, but production figures are not available for publication.

Four carloads of ore were shipped from the Lake Serene mine (Fig. 7-24, No. 70) prior to 1901, and an unknown amount was shipped to the Tacoma smelter in 1949. The ore body consists of mineralized fissures, and high-grade ore is reported to have been worth about $90 a ton.

No ore shipments have been made from the Middle Fork property (Fig. 7-24, No. 86) (also called Clipper group and Gilbreath), but it is reported that drilling in recent years indicates a large potential ore body containing between 0.50 and 1.0 percent copper, with values in gold, silver, and molybdenum. Mineralization is in breccia pipes and along shear zones and cross-fractures in granodiorite.

Shipments of concentrates from the Quartz Creek property (Fig. 7-24, No. 85) were made in 1954. It is reported that, of the two mineralized zones on the property, the one to the east is in a breccia pipe and contains about 150,000 tons of 5-percent copper ore with $7 to $8 in gold and silver per ton; the west ore body is in a shear zone in granodiorite and contains an estimated 4 million tons of 0.7 to 1.0 percent copper ore.

The Sunset mine (Fig. 7-24, No. 69) has produced more copper than any other mine in the Snohomish Basin. Production was spasmodic from 1902 to 1949, but during its periods of operation, 12,912,000 pounds of copper, 1,500 ounces of gold, and 156,000 ounces of silver were taken from the mine. The ore deposit consisted of five main shear zones in granodiorite with lenses of ore a few inches to 16 feet wide. Reserves may be as much as 500,000 tons of ore containing over 1 percent copper plus values in gold and silver.

The Sunrise prospect (Fig. 7-24, No. 58) has had considerable development work done on it, but no ore shipments have been made. The deposit is a mineralized breccia pipe with quartz veinlets extending out from the breccia. The country rock is quartzite and hornfels. The zone is estimated to

contain 4.5 million tons of mineralized material. Assays have run as much as 6 percent copper with values in gold, silver, and molybdenum; however, the overall copper content of the deposit is probably well below 1 percent.

The Mono property (Fig. 7-24, No. 76A) has received considerable attention during the last few years. Drilling in 1965 is reported to have indicated approximately 100,000 tons of ore that is reported to average 1.37 percent copper, 1.22 percent zinc, 0.08 ounce of gold per ton, and 0.98 ounce of silver per ton. The ore body, or bodies (there may be as many as three on the property), consists of silicified and bleached andesite breccia along a granodiorite intrusive contact. There is some question as to whether the mineralized zone is a breccia pipe or a linear shear or breccia zone along the contact. The ore body, so far as past exploration has revealed, is about 60 feet wide, 200 feet long, and over 300 feet deep.

Gold

Gold properties number at least 138 (Fig. 7-24). Ten of these are known or reported to have had production or have made test shipments.

A total of $300,000 in gold and silver was produced from the Apex mine (Fig. 7-24, No. 75) in King County during the years it was worked. Prior to 1901, 300 tons of ore worth $80,000 was taken out; last production was in 1943. Concentrates shipped in 1920 averaged 21 to 26 percent arsenic, 18 to 20 ounces of silver per ton, 1.5 to 2.5 ounces of gold per ton, and 4.5 to 6 percent lead. The ore minerals occur in narrow streaks along a 2- to 6-foot-wide quartz vein in granodiorite.

The Coney Basin mine (Fig. 7-24, No. 81) was worked in 1895, 1934, 1937-39, and 1941. Production from the property in 1895 was 40 tons of ore; figures on total production are not available for publication. The ore body consists of a small persistent quartz vein and a silicified zone that is 4 feet wide. Eight tons shipped to the smelter in 1941 had 0.86 ounce of gold per ton, 19.7 ounces of silver per ton, 0.82 percent copper, 6.0 percent lead, 6.0 percent zinc, 1.52 percent arsenic, and 0.2 percent antimony.

One carload of ore was reportedly shipped in 1909 from the Good Hope mine (Fig. 7-24, No. 55). No information is available as to the type of ore deposit or quality of ore.

Twenty tons of ore were shipped from the Carmack mine (Fig. 7-24, No. 88) prior to 1901. The ore deposit consists of three veins, which are 12 feet, 2 1/2 feet, and 1 foot wide. Assays are reported to have run 1 to 1.5 ounces of gold per ton.

A 23-ton shipment is reported from the Damon and Pythias mine (Fig. 7-24, No. 74) prior to 1940. Assays on the shipment were reported to show 0.87 ounce of gold per ton, 9.0 ounces of silver per ton, and 4 percent lead. Mineralization consists of two veins in granodiorite. One is said to average 3 feet in width over a 900-foot length.

The Index Gold Mines, Inc., mine (Fig. 7-24, No. 62) is reported to have been active in 1939, when shipments of 10 tons per day were being made. No estimate of tonnage shipped is available. Typical assays are said to have shown 5.4 ounces of silver per ton, 6.3 percent lead, 2.5 percent zinc, and 11.59 percent arsenic. Gold values are not known. The ore values are said to be in a vein more than 18 inches wide.

A 1-ton test shipment was made from the Lennox property (Fig. 7-24, No. 79) in 1947. Irregular mineralization is along shear zones that are reported to persist at depth in granite.

A shipment from the Blue Bird mine (Fig. 7-24, No. 59) has been reported, but the amount in unknown. The ore is in a 2-foot zone within a vein that is said to be 27 feet wide.

A small amount of gold is said to have been produced from the Last Chance mine (Fig. 7-24, No. 59A) in 1935. No other information is available.

The Horseshoe Bend Placer (Fig. 7-24, No. 57) gold property on the North Fork of the Snoqualmie River had considerable development work done on it. Values were reported to be 25 cents to 40 cents per yard, and several thousand dollars worth of gold was taken from the property.

Iron

Eight iron properties are known; of these, only one has a record of production, and this was probably a test shipment.

The Anderson property (Fig. 7-24, No. 72) had one carload of ore taken from it. The ore body is a lenticular mass of magnetite with amphibole gangue in a limy quartzite, and presumably is a replacement deposit.

The Lockwood Pyrite (Fig. 7-24, No. 55A) in the Sultan Basin has been extensively drilled during the last few years. Prior to this drilling, it was estimated that the deposit contained over 3.5 million tons of pyrite ore. An average of 75 analyses shows

25 percent iron and 25.6 percent sulfur. Low values in precious metals are present also. The ore deposit consists of three tabular bodies totaling more than 3,000 feet in length and 1 to 75 feet thick in metamorphic rocks.

Molybdenum, Lead, and Nickel

Three molybdenite properties (Fig. 7-24) occur, but none have a record of production.

Eighteen lead properties (Fig. 7-24) are known, but none are reported to have had a record of production. Assays from the various properties indicate that precious metal values are commonly associated with the lead.

Two nickel properties (Fig. 7-24) occur, but neither of them has a record of production. The nickel values are in silica-carbonate rock.

Silver

At least 10 properties have silver as their principal value. Of these, three have a record of production. The Cleopatra mine (Fig. 7-24, No. 83) had intermittent production prior to 1914. It operated again in 1938, 1940, and 1941. Production from the property is reported to have been valued at about $250,000. The deposit consists of altered and mineralized zones along joints in granodiorite.

The Seattle-Cascade mine (Fig. 7-24, No. 77) has a record of a few carloads of lead ore with high silver values being shipped before 1900 and again in 1940. No other production information is available. The ore is in shear zones in granodiorite. The best mineralized zone has an average width of 18 inches.

A test shipment of 500 pounds of ore of unkown grade was made from the Aces Up mine (Fig. 7-24, No. 84). Mineralization is along joints in granodiorite and varies in width from a few inches to 2 feet.

Zinc

No production has been recorded from the three zinc properties (Fig. 7-24).

INTENSIVE LAND USE

The Snohomish Basin is located in Western Washington east of Puget Sound and encompasses the northeast portion of King County and the southern half of Snohomish County. The upper half of the Basin lies in a mountainous expanse which is part of the Cascade Range and the upper forested levels are operated on a sustained yield basis by the Snoqualmie National Forest, the State of Washington and large private timber companies. The rich alluvial lowlands support various types of farming activities.

Population in the cities along Puget Sound in Snohomish Basin increased 94 percent between 1946 and 1966. Intensively used land, therefore, increased accordingly. The Basin has 16 incorporated places and approximately 8 unincorporated places.

INCORPORATED CITIES AND TOWNS

Everett

The city of Everett, county seat of Snohomish County, is located on the east shore of Puget Sound, 29 miles north of Seattle, between the Snohomish River and Port Gardner Bay. Initially settled in 1862, Everett's real development began in 1890 with incorporation of the Everett Land Company and completion of the Great Northern Railroad in 1893. The city was incorporated in 1908.

Everett has a fine harbor which has been a factor in its population growth, and growth as a manufacturing center, with leading industries being lumber and shingles, plywood, pulp and paper, machinery and transportation equipment manufacturing, iron and concrete products, berry and vegetable processing, and dairy and poultry products. Recent establishment of the Boeing 747 plant in the Everett area (Paine Field) is expected to increase employment by 10,000 with a corresponding increase in service industries. The 1967 population of Everett was 52,000, a 12,000 increase since 1960; the projection for 1970, however, is 65,000.

As an entrance point to the mountain loop highway into the Cascades and to Whidbey and Camano Islands, Everett serves as a tourist city. Her waterfront, the Weyerhaeuser Sulphite–Pulp Plant, the site of Vancouver's landing on Port Gardner Bay, and the Tulalip Indian Reservation are local points of interest.

Edmonds

The city of Edmonds is located on Puget Sound approximately 12 miles north of Seattle. Settled in 1866 and incorporated in 1890, Edmonds was for many years little more than a rather wealthy residential suburb of Seattle. The Boeing plant in Snohomish County and local industrial development in areas of shingle making, boat building, manufacture of logging and industrial equipment and commercial flower growing have contributed to Edmond's phenomenal growth increase. Annexation has also added to the recent population spurt. From a 1950 population of 2,057, Edmonds increased 289.7 percent to a 1960 population of 8,016. The 1967 figure, however, was a much increased 21,800.

Mountlake Terrace

The city of Mountlake Terrace is located north of Seattle in Snohomish County near the King County line. It was founded in 1950 on an abandoned airfield and cut-over timber tract, incorporated in 1954, and is a fast-growing residential suburb. A 1960 population of 9,122 had, by 1967, increased to 15,700.

Lynnwood

The city of Lynnwood, slighty northeast of Edmonds in Snohomish County, is a suburban city incorporated in April, 1959. In 1960, the population was reported as 7,207, but by 1967 was 12,585.

Snohomish

The city of Snohomish, situated on the Snohomish River northeast of Seattle, had settlers as early as the 1850's and when Snohomish county was created from part of Island County in 1861, Snohomish was designated county seat. In 1896, eight years after its incorporation, Snohomish lost its county seat position to Everett.

The city has evolved from a lumber center to a trading center for the surrounding agricultural area and has large frozen food companies and other food processing plants. In 1950, population was 3,094, and in 1967, 4,700.

The Puget Sound substation of the Bonneville Power Administration one of the world's largest substations, is located in Snohomish, and distributes power from Grand Coulee Dam to the northwest part of the State.

Marysville

The city of Marysville is located in Snohomish County on the delta of the Snohomish River north of Everett. The town was originally a trading post, and was incorporated in 1891. It is a hybrid; partially a residential suburb for Everett and partially a town in its own right with industries of sawmills, boat building plants, and processing plants for dairy products and strawberries.

Population of Marysville has increased from 2,259 residents in 1950 to 4,000 residents in 1967.

Monroe

The city of Monroe, in Snohomish County on the Skykomish River, stands on the site of Park Place, settled around 1862, but it died when by-passed by the Great Northern Railroad. Platted near Park Place's grave, was Tri-City whose name was changed to Monroe and incorporated in 1902. From a sawmill and logging town, Monroe, as the center of a rich farming community, now has canneries and dairy products plants. A 1950 population of 1,556 had grown to 2,200 in 1967. It is the location of a major State correctional institution.

Snoqualmie

Snoqualmie is in King County on the Snoqualmie River and Snoqualmie Pass Highway east of Seattle. Early settlers staked claims in 1859, but incorporation did not occur until 1903. No real growth took place until 1917 when the Snoqualmie Falls Branch of the Weyerhaeuser Timber Company established the Snoqualmie Falls Lumber Company, still the primary economic source for the town. Population in 1950 was 806, and in 1967, 1,233.

Other incorporated places in the Snohomish Basin are Sultan, incorporated in 1905 with a 1967 population of 975; Skykomish, incorporated in 1909 with a 1967 population of 365; Lake Stevens, incorporated in 1960 with a 1967 population of 1,135; North Bend, with a 1967 population of 1,206 and incorporated in 1909; Gold Bar, incorporated in 1910 with a 1967 population of 350; Index, incorporated in 1907 with a 1967 population of 181; Carnation, incorporated in 1951 with a 1967 popula tion of 532; Duvall, incorporated in 1913, with a 1967 population of 450.

Unincorporated places include Hartford, Machias, Startup, Garland, Halford, Baring, Grotto, and Fall City.

TRANSPORTATION

Rail—The Snohomish Basin is served by the coastal and transcontinental routes of the Great Northern, Northern Pacific and Milwaukee Railroads.

Highways—Interstate Highway No. 5 crossed the basin from south to north. The main developed road up the valley is U.S. Highway No. 2. The area is also served by a network of state and county roads.

Navigation—The Snohomish River, for navigational purposes, is limited to the towing of logs and to certain recreational uses.

Airways—There are numerous small airfields for civilian use in this basin and a major airport facility at Everett.

LAND USE CHARACTERISTICS

There are 1,194,590 acres of land in the Snohomish Basin, and some 23,590 acres of inland water. Table 7-25 contains the figures showing the acreage of the major land uses within the Basin. From Figure 7-21, the land use map of the Snohomish River Basin, it is evident that only a very small percentage of the land in the Basin is now being put to intensive use.

Intensive Land Use

At the present time (1967) intensive land uses occupy some 36,355 acres or 3.0 percent of the Basin's land area. Nearly all of the intensive land use areas are located within or near the Basin's incorporated and unincorporated communities although a few intensive uses will be found at scattered locations throughout the Basin. The following list contains the land use figures for the intensive land use subgroups.

Railroads	Roadways	Airports	Urban (Built-up)	Total
2,288	8,615	1,841	23,611	36,355

Rural Nonagricultural

Part of the land uses classified within the Rural Nonagricultural category are similar in character and often associated with or the forerunners of intensive land use. The following list describes the acreages of each of the subgroups of the Rural Nonagricultural category.

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm yards)	Total
16,550	403	6,261	6,146	29,360

Land Ownership

Of the total land area (1,194,590 acres) in the Snohomish Basin, 24.1 percent is in private ownership; 26.7 percent in private corporate ownership; 38.7 percent in Federal ownership; 9.1 percent in State ownership; and 1.4 percent in local government ownership. The bulk of the private corporate, Federal and State ownerships are forested areas. Land areas owned by local government (city, county and special districts) are largely located in the western third of the Basin and consist mainly of intensive, rural nonagricultural and agricultural land areas.

TRENDS AND POTENTIALS

Intensive land uses in the Snohomish Basin amount to some 36,000 acres or the equivalent of slightly more than one and one-half townships. This area accounts for approximately 3 percent of the total Basin area. Present requirements for intensive land uses are being filled largely in and around Everett and nearby cities. There is presently considerable suburban development occurring in the area due to, (1) local growth and expansion, (2) pressures exerted by the considerable northward growth from the Seattle metropolitan area, and (3) the recent major industrial expansion in the Paine Field area and the expansion of the port of Everett. Within the Snohomish Basin there are approximately eight (8) townships, comprising some 184,000 acres considered most likely to receive pressure for intensive development. These townships are located to the north, east, and south of Everett, encompassing that city as well as the cities of Marysville, Snohomish, Monroe, Edmonds, Lynnwood and Montlake Terrace.

PRESENT AND FUTURE NEEDS

The Snohomish Basin has experienced a boom period of growth with the development of the

Boeing Complex at Paine Field, plus the tremendous growth of the Basin as a suburban area for the Everett-Seattle metropolitan area. Lands have been converted at a spectacular rate the past four years to residential uses, commercial uses, and to a lesser degree, industrial uses.

Present trends suggest the recent activity will continue for a number of years. The whole spectrum of intensive uses will continue to expand within the Basin. Population will almost double by 1980, with equal, or larger increases projected for the 2000 and 2020 planning periods. Without a bridge to Whidbey Island this population growth will increase from 201,300 persons in 1967 to 780,300 persons by the year 2020. This will mean an increase of intensive land use to a total of 87,000 acres by the year 2020. Lands that have been projected as likely to receive pressure for conversion to intensive uses by 2020 total 184,000 acres. Thus, the actual needs at the estimated density of six persons per acre will require slightly less than 50 percent of the 184,000 acres. This will allow the land planners to be selective in the development of the Basin, and to develop the various uses on those lands that are best suited. If a bridge is built between the mainland and Whidbey Island there will be a reduction in the population of about 20,000 persons which will result in a reduction in the acreage required for intensive uses.

Intensive land use acreage projected for the Basin include ample lands for projected industrial land needs. The industrialist will demand lands in and around the Edmonds-Everett-Marysville area. Special care must be taken to properly locate new lands for industry to assure that they are both beneficial to the development of industry, and are not detrimental to other types of uses in the Basin.

Recreation lands must be acquired and developed within the Snohomish Basin to provide areas for recreation for the people of the Basin. There must be a balance of land uses within the Basin throughout the planning period if it is going to remain a desirable place to live.

A plan for the lower 25 miles of the Snohomish River Basin between Monroe and the mouth of the river at Port Gardner was recently published by the consulting firm of Tippetts-Abbett-McCarthy-Stratton for the Snohomish County Economic Development Council. This proposal plans to accomplish, through dredging and land filling, a leveed, greenbelted river channel and a deep-draft harbor with a 3,000-acre industrial and salt water recreational area at the revised river mouth. This $107 million proposed Snohomish River Basin and port development plan will provide the people of the Snohomish Basin, and the entire Puget Sound Area, a rare opportunity to plan for a major multi-use facility on this river basin. It includes industrial, transportation and storage facilities, plus the maintenance of agriculture, and the further development of recreational facilities.

The primary increase in changes of land to intensive uses will be located northeast and south of Everett, as well as some increase in and around the cities of Marysville, Snohomish and Monroe. Development in the future should be limited on the flood plain, except where 100 year protection has been provided. Then development should be selective, such as permitting only industrial development and the restricting of residential development on these "flat" valuable lands. Figure 7-25 portrays the C_2 generalized land use pattern for the Snohomish Basin for the year 2020.

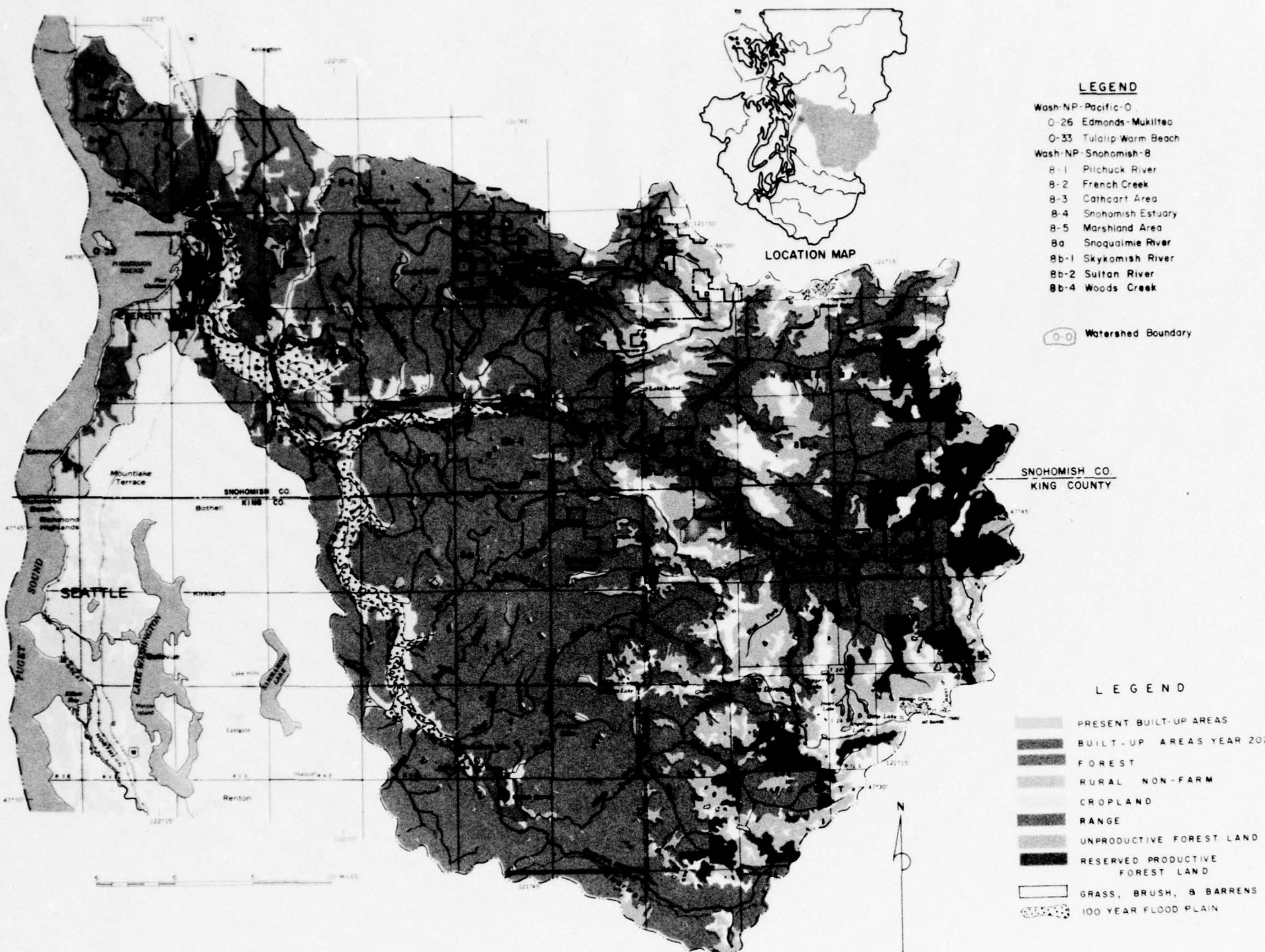
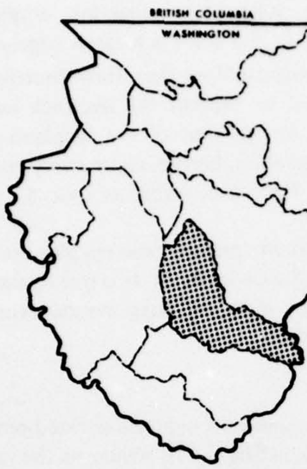


FIGURE 7-25

SNOHOMISH BASIN
GENERALIZED LAND USE MAP
Alternative C2 –2020

CEDAR-GREEN BASINS



The Cedar-Green Basins are located centrally in the Puget Sound Area. Almost all land in these Basins is located in King County. The total hydrologic area is 743,006 acres. There are no major side streams entering either the Cedar or Green Rivers, however the hydrologic area also includes the Sammamish River and several smaller streams entering Lake Washington. The Basins contain the major part of the Seattle metropolitan complex and therefore, the greatest urban development in the Puget Sound Area.

Population

The population of the Basins in 1967 was 1,072,400 persons. This population is primarily located in the western portion of the Basins, in the Seattle metropolitan area. Projections show that the population will grow to 1,479,000 by 1980, 2,375,700 by 2000 and to 3,816,300 persons by the year 2020. This new growth will take place adjacent to the existing areas of development.

Land Use

The largest user of land in the Cedar-Green Basins is forests and associated lands which is 63% of the total of all lands. The other two primary uses, croplands and urban or intensive land uses occupy 7% and 24% respectively. This Basin is the major population and intensive land use center of the Puget Sound Study Area. Table 7-31 shows the tabulation of present land use within the Basins. Figure 7-26 A & B, the generalized land use maps of the Cedar–Green Basins, portrays the land areas occupied by each of the major uses.

TABLE 7-31. Land use in Cedar-Green Basins (in acres)[2]

Map No.	Watershed	Crop-land	Range-land	Total Forest[1]	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
0-27	Swamp, Bear, North Crs.	3,863	80	19,844	11,161	9,847	281	45,076
0-28	Lake Washington	1,660		16,039	3,076	61,721	22,690	105,186
0-29	Upper West Slope Seattle					20,392	1,019	21,411
0-30	Sammamish River	12,084	291	70,617	7,055	11,462	5,632	107,141
0-31	Cedar River	2,672	749	104,141	4,087	3,094	3,266	118,009
	Total Cedar Basin	20,279	1,120	210,641	25,379	106,516	32,888	396,823
0-29	Lower West Slope Seattle	65		893		15,906	63	16,927
0-34	East Side Green River (Black River)	14,579	1,564	34,685	6,224	17,957	2,274	77,283
0-35	West Side Green River (Hill Creek)	8,940	103	7,852	389	14,168	952	32,404
0-36	Lakota-DesMoines	71	30	5,796	949	9,704	41	16,591
0-37	Upper Green River	9,448	535	186,821	1,404	2,150	2,620	202,978
	Total Green Basin	33,103	2,232	236,047	8,966	59,885	5,950	346,183
	Total Cedar-Green Basins	53,382	3,352	446,688	34,345	166,401	38,838	743,006

[1] Includes alpine and other nonforested lands normally associated with forest.

[2] Unadjusted measurements, 1966, Puget Sound Adjacent Waters Study.

AGRICULTURE

PRESENT STATUS AND POTENTIAL CEDAR BASIN

The Cedar Basin is concentrated almost entirely in western King County, with approximately twelve percent of the Basin overlapping into southwestern Snohomish County.

Much of the area consists of alluvial flats and glacial terraces. However, the southeastern section of the Basin has its share of rugged, mountainous areas.

Of the total land area of 363,935 acres in the Cedar Basin, those lands outside the national forest boundaries have been mapped by a medium-intensity soil survey. Lands within the national forest have been mapped by a low-intensity soil survey suitable for reconnaissance use.[1]

Of the 270,201 acres of land mapped by the medium-intensity survey, approximately 228,500 acres are classified in Land Capability Classes II through VI. These 228,500 acres have the greatest potential for development; i.e., changed use, or improvement in use. Land Use Capability Classes II, III, and IV are suited for either cropland or urban uses, and Class VI has potential for urban development.

The Cedar River flows into Lake Washington and drains an area of approximately 185 square miles. It has no major tributaries. The Sammamish River also empties into Lake Washington and its principal tributaries–Swamp, Bear, and North Creeks–drain approximately 238 square miles. Lake Washington empties into Shilshole Bay and drains about 164 square miles. Puget Sound drainage encompasses 33 square miles. The Cedar Basin as a whole drains approximately 620 square miles of territory.

The Cedar Basin provides one of the smaller valley systems in the Puget Sound Area. The system includes many flood and drainage problem areas which require protective measures before their potential can be attained. The lower flood plain contains about 16,000 acres of level or gently undulating bottom lands. The remainder of the land consists of gravelly terraces, with some steep, mountainous valleys in the southeastern section of the Basin.

Production

Farmlands in the Cedar and Sammamish River valleys are gradually being converted to residential and industrial use. The remaining cropland of approximately 20,000 acres is located largely on the rich alluvial lowlands. More than three-fourths of the cropland is used to support the livestock industry. Approximately ten percent of the cropland is used for growing vegetables, berries, and nursery products. Total value of farm production is over $5 million annually.

Forestry at the present time remains the largest user of land in the Cedar Basin. It is one of the major industries in the region, and supports numerous mills and related activities.

Flooding

Climatic conditions induce one flood-producing season annually in the fall or winter as the result of excessive precipitation. Snowmelt in the upper Cedar River is relatively small, and late spring flows are unlikely to cause flooding.

Discharges in excess of channel capacities cause water to spread across the valleys, where it remains until the river drops. In many areas, water is trapped by topographic detail until it can seep into the soil. Excessive rainfall causes similar flooding conditions, as well as swamping of the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV, Watershed Management. Principles and conditions discussed therein apply to the basins included in this Appendix and need not be repeated here.

Watersheds

Five watershed areas requiring solutions to problems, or development to achieve potential productivity of the Cedar Basin, are shown on the Land Use Map (Figure 7-26A) and on the Land Capability Map (Figure 7-27A).

Sammamish River watershed (0-30), with Swamp, Bear, and North Creeks watershed (0-27), comprise the heart of the Cedar Basin agricultural industry. Together they account for 80 percent of all cropland in the Basin. Almost half of the forest lands of the Cedar Basin lies in these two watersheds. Urbanization, consisting mainly of housing developments, is progressing in the uplands on both sides of

[1] Parts of Seattle have been mapped by a high-intensity soil survey.

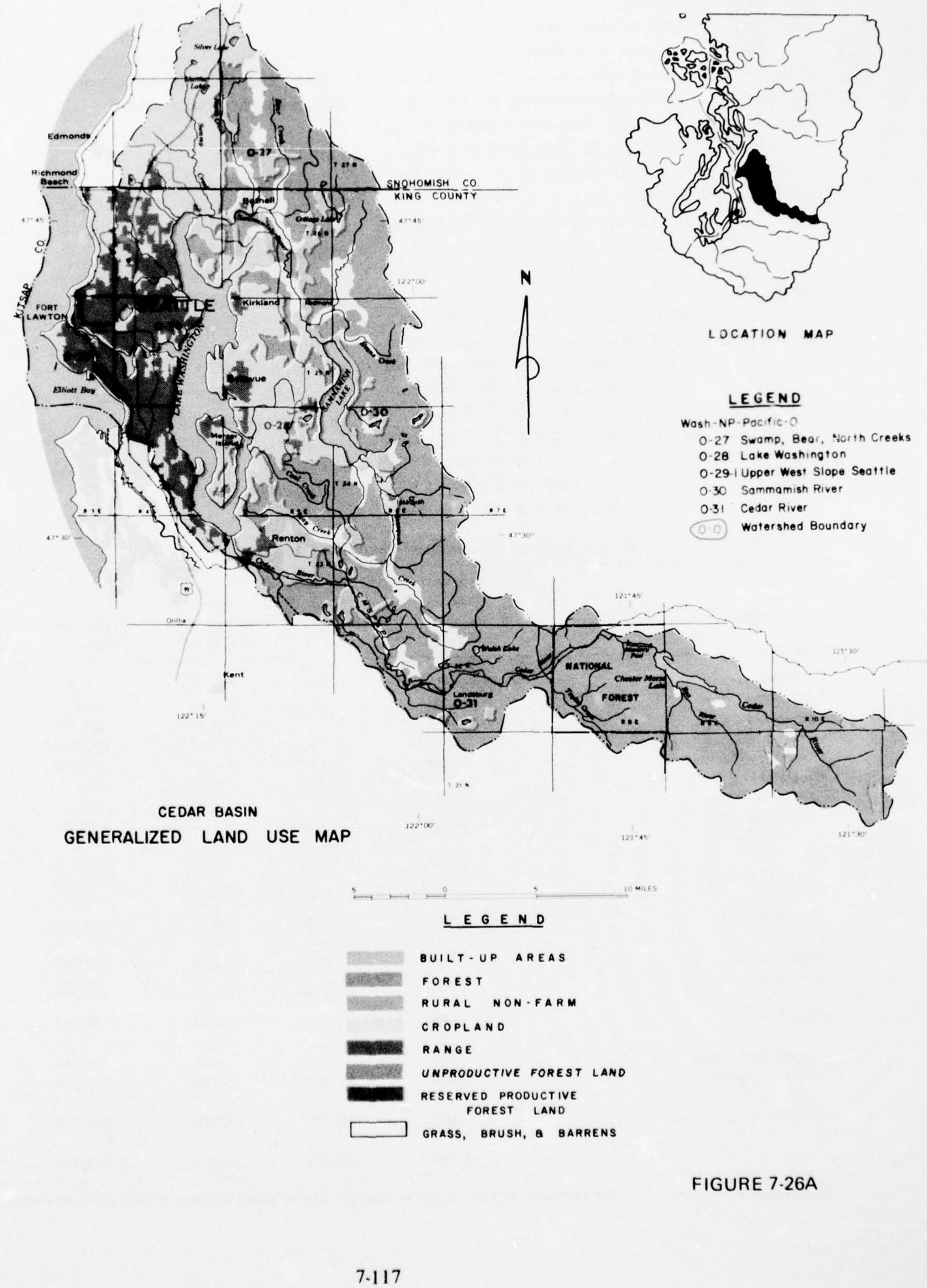

LOCATION MAP
LEGEND
Wash-NP-Pacific-O
O-27 Swamp, Bear, North Creeks
O-28 Lake Washington
O-29-I Upper West Slope Seattle
O-30 Sammamish River
O-31 Cedar River
Watershed Boundary
Edmonds
Richmond Beach
SNOHOMISH CO.
KING COUNTY
KITSAP CO.
FORT LAWTON
SEATTLE
Elliott Bay
LAKE WASHINGTON
Kirkland
Bothell
Bellevue
Renton
Kent
Landsburg
NATIONAL FOREST
N
CEDAR BASIN
GENERALIZED LAND USE MAP
10 MILES
LEGEND
BUILT-UP AREAS
FOREST
RURAL NON-FARM
CROPLAND
RANGE
UNPRODUCTIVE FOREST LAND
RESERVED PRODUCTIVE FOREST LAND
GRASS, BRUSH, & BARRENS

FIGURE 7-26A

Sammamish Lake. Potential development leans toward more urbanization, with forestry and farming continuing to play significant roles.

Lake Washington watershed (0-28) has very little cropland and not much forest land. It is highly urbanized, containing approximately 60 percent of the built-up areas of the Basin. The potential of the watershed consists of a high concentration of urbanization and further development of the recreational uses of Lake Washington.

West Slope Seattle watershed (0-29) consists entirely of built-up areas, with some fresh waters. A higher degree of urbanization is foreseen for the future.

Cedar River watershed (0-31) is the least urbanized of the five watersheds. The importance of this watershed lies largely in its municipal and national forest lands and in the fact that the Cedar River is the principal source of water for the city of Seattle. Agriculture in this watershed is of slight importance. The potential lies in its forested lands and water source area, and in continued urbanization.

Many of the farmlands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions will be summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the Cedar Basin is shown in Table 7-31. The following tables are to indicate the potential development possible within acceptable land use standards.

Table 7-32 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-33 shows the number of acres in each capability class, subclass, and unit by watersheds in the Cedar Basin. This table can be used with the description on capability units to estimate the potential for development.

TABLE 7-32. Distribution and value of production by crops in Cedar Basin

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	44	81	.40	3,897	.18
Field crops	20	36	.18	10,745	.50
Vegetables	916	1,689	8.33	362,444	16.83
Berries	119	220	1.08	226,464	10.52
Nursery products	94	174	.86	303,505	14.09
Cropland not used	701	1,292	6.37	--	--
Sub-Total	1,894	3,492	17.22	907,055	42.12
Hay	2,189	4,036	19.90	189,172	8.79
Hay aftermath	--	--	--	118,164	5.49
Sub-Total	2,189	4,036	19.90	307,336	14.28
Silage (grass)	549	1,012	4.99	67,050	3.11
Grass aftermath	--	--	--	29,687	1.38
Sub-Total	549	1,012	4.99	96,737	4.49
Silage (corn) fodder	204	375	1.85	24,849	1.15
Pasture (cropland)	6,164	11,364	56.04	817,357	37.96
Sub-Total	9,106	16,787	82.78	1,246,279	57.88
Total	11,000	20,279	100.00	2,153,334	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.

TABLE 7-33. Land capability units in Cedar Basin (in acres) [1]

Capability Units[2]	WATERSHEDS 0-27	0-28	0-29	0-30	0-31	Total
II ws 02	30			236	85	351
II ws 03	182	793		1,910	1,153	4,038
II ws 04	418	220		2,555	153	3,346
II ws 06	1,626	1,599	42	2,296	517	6,080
Class II Total	2,256	2,612	42	6,997	1,908	13,815
III ew 01	227	2,776	512	3,165	479	7,159
III ws 01		33				33
III ws 05				1,073		1,073
III ws 08	407	15				422
III ws 09	2,524	1,185	81	996	258	5,044
III ws 10	80					80
III so 01	15					15
III so 08				15		15
III sw 09	75	15		165		255
Class III Total	3,328	4,024	593	5,414	737	14,096
IV ew 22	25,733	34,824	2,619	37,994	16,535	117,705
IV es 09		748		653	502	1,903
IV ws 05				94		94
IV ws 06	895	98	20	238	295	1,546
IV ws 10	75	820	13	689	101	1,698
IV so 01	35	199		5,046	11,627	16,907
IV se 05	261	4,368	60	1,287	257	6,233
IV sw 09	135			165		300
Class IV Total	27,134	41,057	2,712	46,166	29,317	146,386
Class II-IV Total	32,718	47,693	3,347	58,577	31,962	174,297

[1] Does not include lands within national forest boundaries. Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

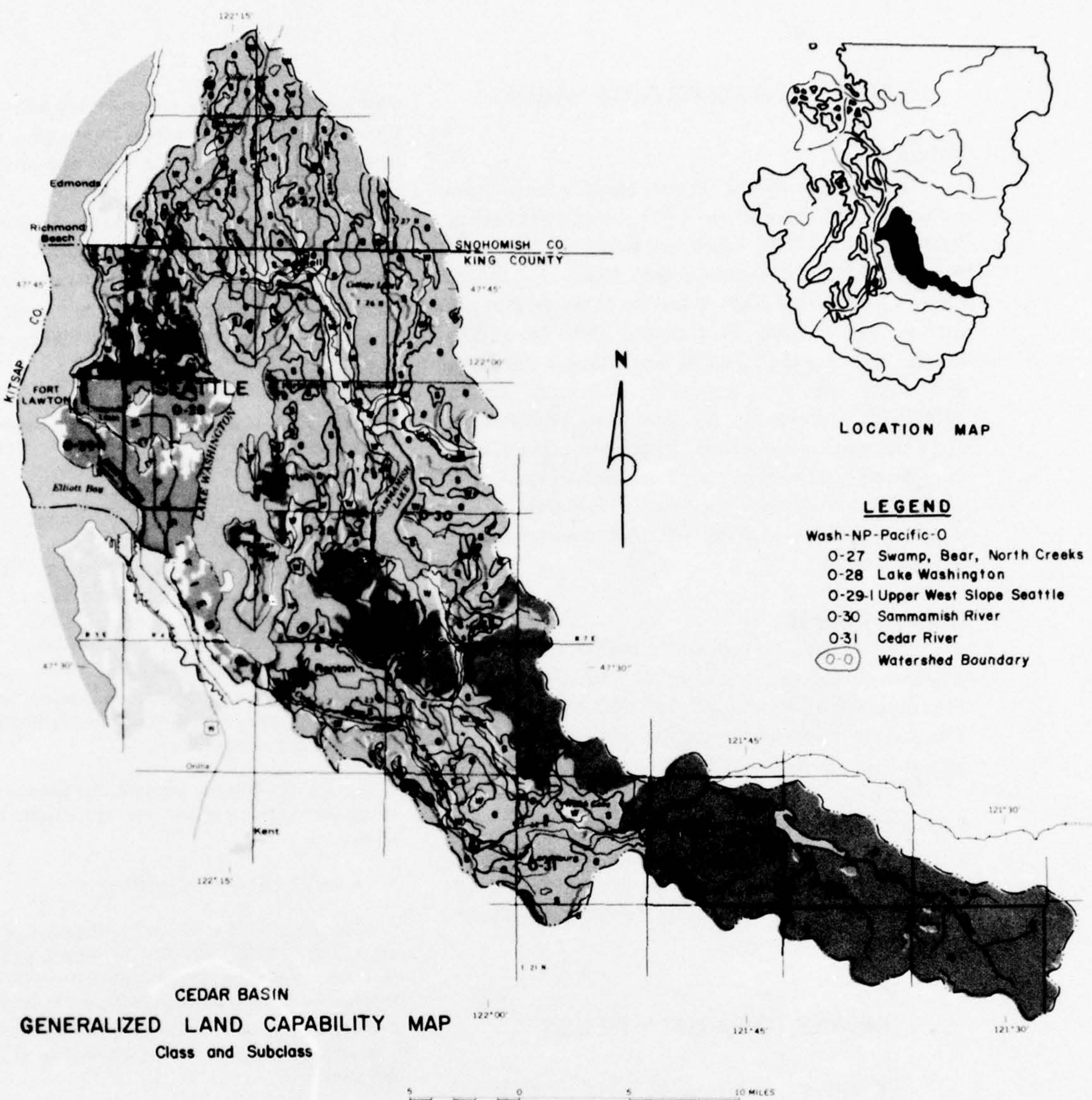
[2] See Exhibit 1 for description of capability units.

TABLE 7-33. **Land capability units in Cedar Basin (in acres)[1] (cont.)**

Capability Units[2]	WATERSHEDS 0-27	0-28	0-29	0-30	0-31	Total
V ws 21		86		492	86	664
Class V Total		86		492	86	664
VI ew 21	3,261	6,406	1,000	6,420	1,025	18,112
VI es 19	1,409	2,293	713	2,543	2,859	9,817
VI es 20		159		590		749
VI es 22					364	364
VI ws 19		206		190	867	1,263
VI so 01		7		803	729	1,539
VI so 18	1,478	1,893	139	3,116	110	6,736
VI se 13					50	50
VI se 17	5,623	3,633	465	4,486	752	14,959
Class VI Total	11,771	14,597	2,317	18,148	6,756	53,589
VII es 35					56	56
VII es 36	200	6,184	56	23,981	9,937	40,358
Class VII Total	200	6,184	56	23,981	9,993	40,414
VIII ew 39		30	47	57		134
VIII ws 00		40		31	276	347
VIII ws 23	15	47		7	15	84
VIII ws 24	91	47		209	147	494
VIII so 00		121	1	11	45	178
Class VII Total	106	285	48	315	483	1,237
Class V-VIII Total	12,077	21,152	2,421	42,936	17,318	95,904
Class II-VIII Total	44,795	66,845	5,768	101,518	49,280	270,201

[1] Does not include lands within national forest boundaries. Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

[2] See Exhibit 1 for description of capability units.



CEDAR BASIN

GENERALIZED LAND CAPABILITY MAP

Class and Subclass

LEGEND

LAND SUITED FOR CULTIVATION AND OTHER USES

I Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

IV Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

V Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

VI Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

VII Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

VIII Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

FIGURE 7-27A

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the Cedar Basin will increase from 776,500 people in 1963 to approximately 3,035,200 by 2020, based on Regional Economic Studies Technical Committee data. Due to the limitations of land in this Basin, a density of six persons per acre is only feasible to the year 1980 by adding 64,105 acres to the 131,895 acres already in urban and rural nonfarm use. For the time period 1980-2000, the density per acre must be raised to eight and approximately 40,175 acres must be added. Population pressure in the 2000-2020 period will bring about a density per acre of ten persons and require an increase in urban and rural nonfarm area of 67,345 acres.

Cropland Needs

The Cedar Basin presently has 20,279 acres of cropland. Urbanization and other uses. are expected to reduce this to approximately 7,500 acres by 2020. The percent increases needed, by crops, for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Table 7-34 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Cedar Basin is summarized under the topic "Program Implementation" immediately following "Forestry." A more complete description is found in Appendix XIV, Watershed Management

TABLE 7-34. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	12,703[2]	12,703[2]	12,703
Watershed protection and rehabilitation[3]	acre	15,120	13,120	8,620
Drainage improvement	acre	3,250	5,417	7,223
Irrigation development[4]	acre	2,000	3,000	6,000
Water for irrigation[5]	acre	4,300	6,450	12,900

1 In the Cedar Basin, 27,227 acres are subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated here.

2 The year 2000 figure includes 703 acres of land expected to go into urban use and the 2020 figure includes 5,203 acres.

3 Includes 1,120 acres of rangeland.

4 According to Appendix VII, Irrigation, there were 800 acres (using 1,720 acre feet of water) irrigated in 1966. Irrigation Appendix projections show 400 acres will be irrigated by 1980; 0 acres by 2000; and 0 acres by 2020.

5 Based on gross diversion requirements of 2.15 acre feet per acre, estimated by Irrigation Committee in Appendix VII, Irrigation.

PRESENT STATUS AND POTENTIAL GREEN BASIN

The Green Basin is located almost entirely in southern King County, with less than one percent of the Basin overlapping into northwestern Pierce County.

Approximately half of the area is mountainous. Of the total land area of 340,233 acres in the Basin, those lands outside the national forest boundaries have been mapped by a medium-intensity soil survey. Lands within the national forest boundaries have been mapped by a low-intensity soil survey suitable for reconnaissance use. Of the 208,699 acres mapped with the medium-intensity soil survey, nearly 149,000 acres are classified in Land Use Capability Classes II through VI. [1]

These 149,000 acres of land have the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, and IV are suited for either cropland or urban uses, and Class VI has potential for urban developments.

The Green River is one of the smaller rivers in the Puget Sound Area. It drains an area of 541 square miles. The principal tributaries are Soos Creek and Newaukum Creek. The system includes many flood and drainage problem areas which require corrective measures before their potential can be attained. The lower flood plain contains about 17,000 acres of level or gently undulating bottom lands. Another acreage of the problem area is in the Osceola plateau. The undeveloped lands start at the foothills and graduate into sizeable areas of steep, mountainous valleys in the eastern section of the Basin.

Production

Land usage in the Green Basin is in a transitional stage from agriculture to industrial-commercial. The remaining cropland of 33,000 acres is located largely on the rich alluvial lowlands. More than three-fourths of the cropland is used to support the livestock industry. Approximately 10 percent of the cropland is used for growing vegetables, berries, and nursery products. Total value of farm production is over $8 million annually.

Forests, the largest user of land in the Basin, provides exports of wood products to adjoining basins for processing. There are no large sawmills or wood pulp producing mills located in the Green Basin.

Flooding

Climatic conditions induce one flood-producing season annually, in the fall or winter, as the result of excessive precipitation.

With the completion of the Howard H. Hansen Dam, overbank flooding by the Green River is substantially eliminated. Flooding from minor tributaries is still a major problem. In many areas, water is trapped by topographic detail until it can seep into the soil. Excessive rainfall causes similar flooding conditions, as well as swamping of the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV, Watershed Managment. Principles and conditions discussed therein apply to the Green Basin and need not be repeated here.

Watersheds

Five watershed areas requiring solutions to problems or development to achieve potential productivity of the Basin are shown on Land Use Map (Figure 7-26A) and on the Land Capability Map (Figure 7-27B).

Lower West Slope Seattle watershed (0-29) is almost completely urbanized.

East Side Green River watershed (0-34) contains 44 percent of the croplands of the basin, and 30 percent of its urban areas. Forest land is of minor importance. Potential of the watershed appears to be urbanization, first, and farming to a lesser extent.

West Side Green River watershed (0-35) has a high degree of urban concentration, along with a significant amount of dairy farming. Considerable amounts of vegetables and cane fruits are also produced. Potential use leans toward a higher degree of urbanization.

Lakota-Des Moines watershed (0-36) consists mainly of urban areas, with a small amount of forest. Farming is almost nonexistent. Urbanization is likely to continue to be the most important development in the future.

Upper Green River watershed (0-37) contains 80 percent of the forest land in the Green Basin. A large part of this forest land (approximately 63 percent) lies within the Snoqualmie National Forest. A large area of the upper watershed is owned or controlled by the city of Tacoma for the production

[1] Parts of Seattle have been mapped by a high-intensity soil survey.

TABLE 7-35. Distribution and value of production by crops in Green Basin

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	39	75	.23	3,618	.10
Field crops	28	55	.17	16,411	.47
Vegetables	1,412	2,742	8.28	588,470	16.82
Berries	175	339	1.02	349,082	9.98
Nursery products	153	298	.90	519,795	14.86
Cropland not used	1,139	2,212	6.68	--	--
Sub-Total	2,946	5,721	17.28	1,477,376	42.23
Hay	3,381	6,565	19.83	307,713	8.80
Hay aftermath	--	--	--	191,476	5.47
Sub-Total	3,381	6,565	19.83	499,189	14.27
Silage (grass)	779	1,512	4.57	100,177	2.86
Grass aftermath	--	--	--	44,101	1.26
Sub-Total	779	1,512	4.57	144,278	4.12
Silage (corn) fodder	300	583	1.76	38,628	1.10
Pasture (cropland)	9,642	18,722	56.56	1,339,211	38.28
Sub-Total	14,102	27,382	82.72	2,021,306	57.77
Total	17,048	33,103	100.00	3,498,682	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.

of water for the city. At present much of the cropland is in pasture for dairy farms. Urbanization is of small significance within this watershed. The potential seems to be for forest products, and as a water source area.

Many of the farmlands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions are summarized in the Puget sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the Green Basin is shown in Table 7-31. The following tables are to indicate the potential development possible within acceptable land use standards.

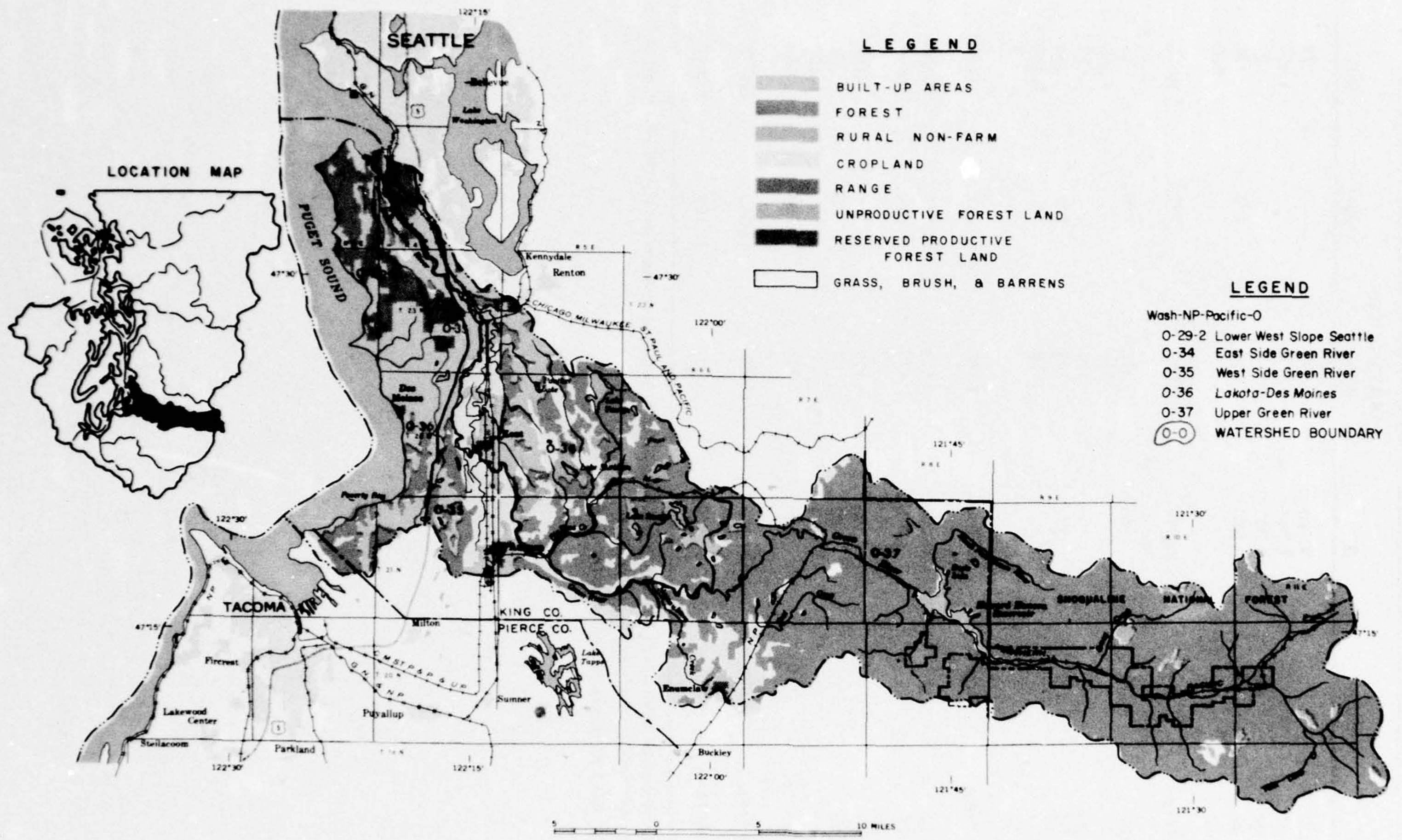
Table 7-35 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-36 shows the number of acres in each capability class, subclass, and unit, by watersheds, in the Green Basin. This table can be used with the description of capability units to estimate the potential for development.

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the Green Basin will increase from 200,200 in 1963 to approximately 781,100 by 2020, based on Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 68,581 acres presently in intensive and rural nonagricultural use could provide ample acreage for new intensive development to the year 1980 without encroachment onto the croplands of the Basin. By



GREEN BASIN
GENERALIZED LAND USE MAP

FIGURE 7-26B

TABLE 7-36. Land capability units in Green Basin (in acres)[1]

Capability Units[2]	WATERSHEDS 0-29	0-34	0-35	0-36	0-37	Total
II ws 02		1,723	1,390		73	3,186
II ws 03		6,747	6,366		1,066	14,179
II ws 04	40	1,760	2,183		37	4,020
II ws 06	74	1,522	756	172	770	3,294
II ws 09					529	529
Class II Total	114	11,752	10,695	172	2,475	25,208
III ew 01	279	48	21	228	15	591
III we 17			395		1,566	1,961
III ws 05		155	409		22	586
III ws 09	127	851	85	123	254	1,440
III ws 10			535		3,554	4,089
III ws 12					9	9
Class III Total	406	1,054	1,445	351	5,420	8,676
IV ew 22	6,220	31,207	10,813	11,845	6,336	66,421
IV es 09		1,076	479		3,664	5,219
IV ws 05		58	7			65
IV ws 06		103	177	14	310	604
IV ws 10		289	77	66	58	490
IV so 01		8,064			9,932	17,996
IV se 05	701	306	274	658	452	2,391
Class IV Total	6,921	41,103	11,827	12,583	20,752	93,186
Class II-IV Total	7,441	53,909	23,967	13,106	28,647	127,070

[1] Does not include land within national forest boundaries. Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

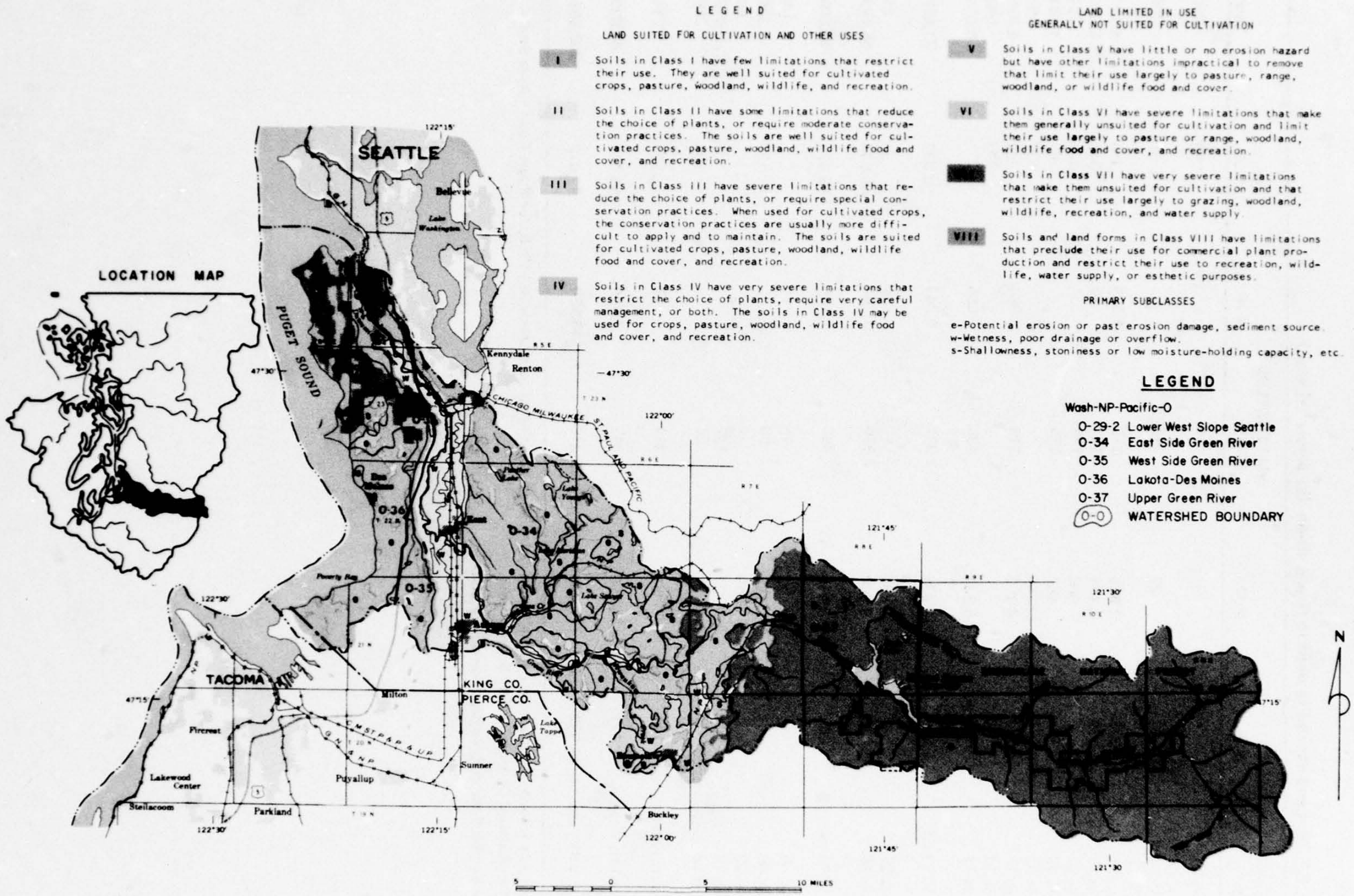
[2] See Exhibit 1 for description of capability units.

TABLE 7-36. Land capability units in Green Basin (in acres)[1] (cont.)

Capability Units[2]	WATERSHEDS 0-29	0-34	0-35	0-36	0-37	Total
V ws 21		97	44		89	230
Class V Total		97	44		89	230
VI ew 21	276	2,524	379	1,239	356	4,774
VI es 19	24	1,181	131	45	948	2,329
VI es 20		608	192		482	1,282
VI ws 19		485	575		97	1,157
VI so 01		30			137	167
VI so 18	183	4,469	319	364	85	5,420
VI se 13	10				932	942
VI se 17	946	3,538	435	595		5,514
Class VI Total	1,439	12,835	2,031	2,243	3,037	21,585
VII es 35		35			36	71
VII es 36	1,065	3,380	2,960	1,184	49,940	58,529
Class VI Total	1,065	3,415	2,960	1,184	49,976	58,600
VIII ew 39	43	12	15	17		87
VIII ws 00		167	95		133	395
VIII ws 23		59	7			66
VIII ws 24	64	137	172		5	378
VIII so 00		77	25		186	288
Class VIII Total	107	452	314	17	324	1,214
Class V-VIII Total	2,611	16,799	5,349	3,444	53,426	81,629
Class II-VIII Total	10,052	70,708	29,316	16,550	82,073	208,699

[1] Does not include lands within national forest boundaries. Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

[2] See Exhibit 1 for description of capability units.



GREEN BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

FIGURE 7-27B

the year 2000, about 12,200 additional acres will be needed to hold the density per acre to six, with a further addition of 49,130 acres needed by 2020.

Cropland Needs

The Basin presently has 33,103 acres of cropland. Urbanization and other uses are expected to reduce this acreage to approximately 17,500 acres by 2020. The percent increases needed by crops for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Data in Table 7-37 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Green Basin is summarized under the topic "Program Implementation" immediately following "Forestry." A more complete description is found in Appendix XIV, Watershed Management.

TABLE 7-37. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	17,910	17,910[2]	17,910
Watershed protection and rehabilitation[3]	acre	27,232	24,732	19,732
Drainage Improvement	acre	7,447	12,411	16,548
Irrigation development[4]	acre	5,000	7,000	14,000
Water for irrigation[5]	acre	10,750	15,050	30,100

[1] A total of 36,678 acres in the Green Basin are subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated here.

[2] Includes 410 acres expected to go urban

[3] Includes 2,232 acres of rangeland.

[4] According to Appendix VII, Irrigation, there were 1,800 acres (using 3,870 acre feet of water) irrigated in 1966. Irrigation Appendix projections show 1,400 acres irrigated by 1980, 900 acres by 2000, and 1,100 acres by 2020.

[5] Based on gross diversion requirements of 2.15 acre feet per acre, estimated by Irrigation Committee in Appendix VII, Irrigation.

FORESTS

PRESENT STATUS

Over half of the land in the Cedar-Green Basins is classified as forest land. This amounts to 397,760[1] acres, or 54% of the hydrologic area (Table 7-38). Forests are concentrated primarily in the eastern half of the Basins, about 75,000 acres of which are in the municipal watershed for the city of Seattle, primarily within the Cedar River drainage. Only 7,000 acres is held in reserved status. Classification of the available forest land by resource zones is shown in the tabulation below:

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	105,140	27
Principal Forest	232,780	60
Upper Forest	51,880	13
Subalpine	--	0
Total available	389,800	100

[1] Does not include nonforested lands commonly associated with forest areas.

TABLE 7-38. Cedar-Green Basins—Area of forest land, in acres, by ownership and type

	Available							
Cover Type or Land Class	National Forest	State County	Muni-cipal	Indian	Private	Total Avail.	Unavail-able	Total Avail. & Unavail.
Douglas-Fir								
seedlings and saplings	500	--	220	--	17,830	18,550	240	18,790
poletimber	3,800	2,070	17,050	10	40,970	63,900	720	64,620
small young growth sawtimber	13,220	1,760	7,940	10	27,300	50,230	3,190	53,420
old growth and large young growth sawtimber	6,720	1,230	7,540	--	10,420	25,910	2,130	28,040
True fir—mountain hemlock								
seedlings and saplings	320	3,710	1,500	--	1,570	7,100	30	7,130
poletimber	990	--	--	--	1,570	2,560	--	2,560
small sawtimber	9,580	--	--	--	6,270	15,850	--	15,850
large sawtimber	13,720	--	11,020	--	--	24,740	180	24,920
Western hemlock								
seedlings and saplings	650	--	6,040	--	5,090	11,780	170	11,950
poletimber	330	--	3,030	--	9,020	12,380	50	12,430
small sawtimber	4,070	--	1,530	--	14,440	20,040	50	20,090
large sawtimber	9,970	1,230	2,990	--	8,780	22,970	50	23,020
Western redcedar								
poletimber	--	--	--	--	1,470	1,470	--	1,470
small sawtimber	330	--	--	--	5,000	5,330	10	5,340
large sawtimber	330	--	1,500	--	--	1,830	30	1,860
Sitka—Englemann spruce								
small sawtimber	--	--	--	--	1,470	1,470	--	1,470
large sawtimber	160	--	--	--	--	160	--	160
Western white pine								
poletimber	170	--	--	--	30	200	--	200
small sawtimber	170	--	--	--	--	170	--	170
SUBTOTAL, softwoods	65,030	10,000	60,360	20	151,230	286,640	6,850	293,490
Hardwoods								
seedlings and saplings	170	520	30	--	4,490	5,210	10	5,220
poletimber	490	--	9,170	20	53,590	63,270	510	63,780
small sawtimber	1,160	--	80	10	17,620	18,870	440	19,310
large sawtimber	--	--	--	--	1,040	1,040	--	1,040
SUBTOTAL, hardwoods	1,820	520	9,280	30	76,740	88,390	960	89,350
Nonstocked								
cutover	990	--	2,840	--	3,570	7,400	50	7,450
deforested by fire	--	--	--	--	60	60	--	60
SUBTOTAL, nonstocked	990	--	2,840	--	3,630	7,460	50	7,510
TOTAL, productive land	67,840	10,520	72,480	50	231,600	382,490	7,860	390,350
Subalpine	--	--	--	--	--	--	--	--
Noncommercial, rocky	2,630	--	4,160	--	520	7,310	100	7,410
TOTAL, unproductive	2,630	--	4,160	--	520	7,310	100	7,410
TOTAL, all forested land	70,470	10,520	76,640	50	232,120	389,800	7,960	397,760

The Cedar-Green Basins contain 382,490 acres of commercial forest land capable of producing continuous crops of industrial wood. The sawtimber inventory supported on these lands is 6.1 billion board feet, International ¼-inch Rule (Table 7-39). The figures cited represent 7.6% of Puget Sound Area's commercial forest land and 6.0% of the available sawtimber volume. Privately owned forest lands within the Cedar-Green Basins total 231,600 acres. These are divided into 123,700 acres in large holdings, 2,800 acres in medium sized ownerships and 105,100 acres in small ownerships. The latter acreage is located in the middle and western portions of the Basins. Public lands, located in the upper Basin, include 150,900 acres of commercial timber land. Ownership is 48% municipal, 45% National Forest, and 7% State and County.

The Cedar-Green Basins support a surprisingly large forest products industry considering the proximity to the metropolitan areas of Seattle and Tacoma. There are 25 wood-using plants located in the Basins. Six of these are fully integrated plants located in Seattle. These require over a million board feet of logs per day. This figure increases materially in high market periods when additional shifts are added at the mills. Products are lumber, plywood, treated poles and pilings, chips, shakes and shingles, moulding, and other specialty products. The remaining 19 plants, located throughout the valleys, are smaller. These produce fencing, lumber, car stock, moulding, chips, speicalty products, and veneer. The 19 smaller plants require 100,000 to 200,000 board feet of logs each day.

Problems of Cedar-Green Basins are not as great as those found in other Basins. Good forest land management is available on most ownerships, particularly on national forests, large private ownerships, and on the municipal lands. The most difficult conflict to resolve is found in the demand for recreation lands as opposed to land designated for municipal water supply purposes and timber harvest under controlled conditions.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

No determination of the demand for wood products is made specifically for the Cedar-Green Basins. The nature of the forest products industries, particularly the relative ease of log transportation between the basins, would make such a determination rather meaningless. In addition, a specific figure would imply that a production goal was established for the Puget Sound Area as a whole, with the assumption that considerable shifts in production between the basins will occur, depending upon the actual pattern of industrial and land use development.

For sake of basin comparison, however, there is some value in showing the percentage of demand that may be supplied by the Cedar-Green Basins in the future. In 2020, the Basins are expected to contain about 7% of the commercial forest land in the Puget Sound Area. The percentage in earlier periods is slightly lower. It is therefore assumed that the Basins will supply approximately 7% of the total wood products demand in the future.

The effect of competing uses for forest lands is discussed in detail in the section covering the Puget Sound Area. The estimated diversion of forest land from these causes in the Cedar-Green Basins is shown below:

Type of Land Diversion	Acres Diverted (2020)
Parks, Wilderness, Campgrounds or other Recreation Use	2,580
Roads and Highways	10,250
Urban-Industrial Development	77,000
Reservoirs, Powerlines, and other miscellaneous conversion	1,500
Private Land Use Reservations	20,000
Total	111,330

TABLE 7-39. Cedar-Green Basins—Volume of sawtimber and growing stock, by ownership, on productive forest land

Species or Group	Available: National Forest	State & County	Municipal	Indian	Private	Total Available	Unavail-able	Total Available & Unavailable
Sawtimber—Thousand board feet, International ¼-inch Rule								
Douglas fir								
small sawtimber	199,040	28,810	147,190	130	445,530	820,700	39,020	859,720
large sawtimber	272,910	67,140	428,530	20	597,090	1,465,690	81,550	1,547,240
True fir—mountain hemlock								
small sawtimber	166,750	1,910	700	--	105,150	274,510	10	274,520
large sawtimber	845,170	1,910	597,650	--	3,340	1,448,070	10,990	1,459,060
Western hemlock								
small sawtimber	61,100	--	32,970	--	223,830	317,900	920	318,820
large sawtimber	523,200	64,240	169,440	--	459,030	1,215,910	2,640	1,218,550
Western redcedar								
small sawtimber	6,780	--	--	--	80,450	87,230	220	87,450
large sawtimber	29,530	--	81,260	--	2,030	112,820	2,140	114,960
Other softwood species								
small sawtimber	3,180	--	--	--	40	3,220	--	3,220
large sawtimber	8,930	--	--	--	24,170	33,100	--	33,100
SUBTOTAL, softwoods	2,216,590	164,010	1,457,740	150	1,940,660	5,779,150	137,490	5,916,640
Hardwoods								
small sawtimber	12,260	160	7,890	120	223,310	243,740	5,060	248,800
large sawtimber	390	160	7,130	20	83,850	91,550	410	91,960
SUBTOTAL, hardwoods	12,650	320	15,020	140	307,160	335,290	5,470	340,760
TOTAL SAWTIMBER, all species	2,229,240	164,330	1,472,760	290	2,247,820	6,114,440	142,960	6,257,400
Growing Stock—Million cubic feet								
Douglas-fir	104.2	17.5	104.9	0.0	190.0	416.6	22.0	438.6
True fir-mountain hemlock	183.0	0.7	108.2	--	19.6	311.5	2.0	313.5
Western hemlock	113.9	12.5	39.4	--	133.1	298.9	0.7	299.6
Other softwood species	19.2	--	32.2	--	42.2	93.6	0.9	94.5
SUBTOTAL, softwoods	420.3	30.7	284.7	0.0	384.9	1,120.6	25.6	1,146.2
Hardwoods	5.0	0.1	5.9	0.1	121.4	132.5	2.2	134.7
TOTAL GROWING STOCK all species	425.3	30.8	290.6	0.1	506.3	1,253.1	27.8	1,280.9

The current and prospective changes in the commercial forest land base from all causes are given below:

Current and projected commercial forest area in the Cedar-Green Basins 1965-2020 (in thousand acres)

	Ownership						
	Private			Public			
Period	Large	Medium	Small	NF	Other Federal	Other	Total
1965	123.7	2.8	105.1	67.8	--	83.1	382.5
1980	122.6	2.8	83.1	66.5	--	82.0	357.0
2000	121.6	2.8	48.2	64.9	--	80.8	318.3
2020	119.9	2.7	5.9	63.2	--	79.5	271.2

Specific measures for soil and water protection are discussed in Appendix XIV, Watershed Management.

CEDAR BASIN PROGRAM IMPLEMENTATION

In order to satisfactorily take care of the needs of the Cedar Basin, as emphasized in the preceding pages, the following plan has evolved. It is multipurpose in scope and will provide for floodwater damage prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development. Other measures provide for water quality and quantity control, recreation, and fish and wildlife development.

This plan includes programs and projects designed to accomplish specific objectives of conservation and development. They provide for the full development of lands expected to remain in cropland use in 2020. Less than half of the present cropland will remain by 2020, with the rest going to other uses.

The plan is broken down into three time periods: (a) early action (within the next ten years), (b) near future (1980-2000), and (c) distant future (2000-2020).

Program measures are onsite practices which take advantage of development made possible by the structural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management, and irrigation development. Total cost of the program for the early action period is $11,820,000.

There are two early action projects described in Appendix XIV, Watershed Management. Primary agricultural benefits from these projects are attributed to prevention of flooding and drainage improvement. The two projects are expected to cost $118,900 annually, and to result in annual benefits of $241,900, for a benefit-to-cost ratio of 2.0 to 1.

Three projects with an installation cost of $3,810,000 are proposed for the period between 1980 and 2000; and one project costing $100,000 will be installed after the year 2000. Program costs are expected to be $16,102,000 for the period after 1980 and $15,693,000 for the period after 2000.

Total cost of the plan is expected to be $49,705,000.

A summary of the early action projects is given in Table 2-21 of the Puget Sound section on agriculture. A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, Watershed Management, Cedar Basin section.

GREEN BASIN PROGRAM IMPLEMENTATION

To sufficiently provide for the needs of the Green Basin, as brought out in the preceding section, the following plan has been designed. This plan, multipurpose in nature, will provide for floodwater damage prevention, watershed protection and rehabilitation, drainage improvement, and irrigation develop-

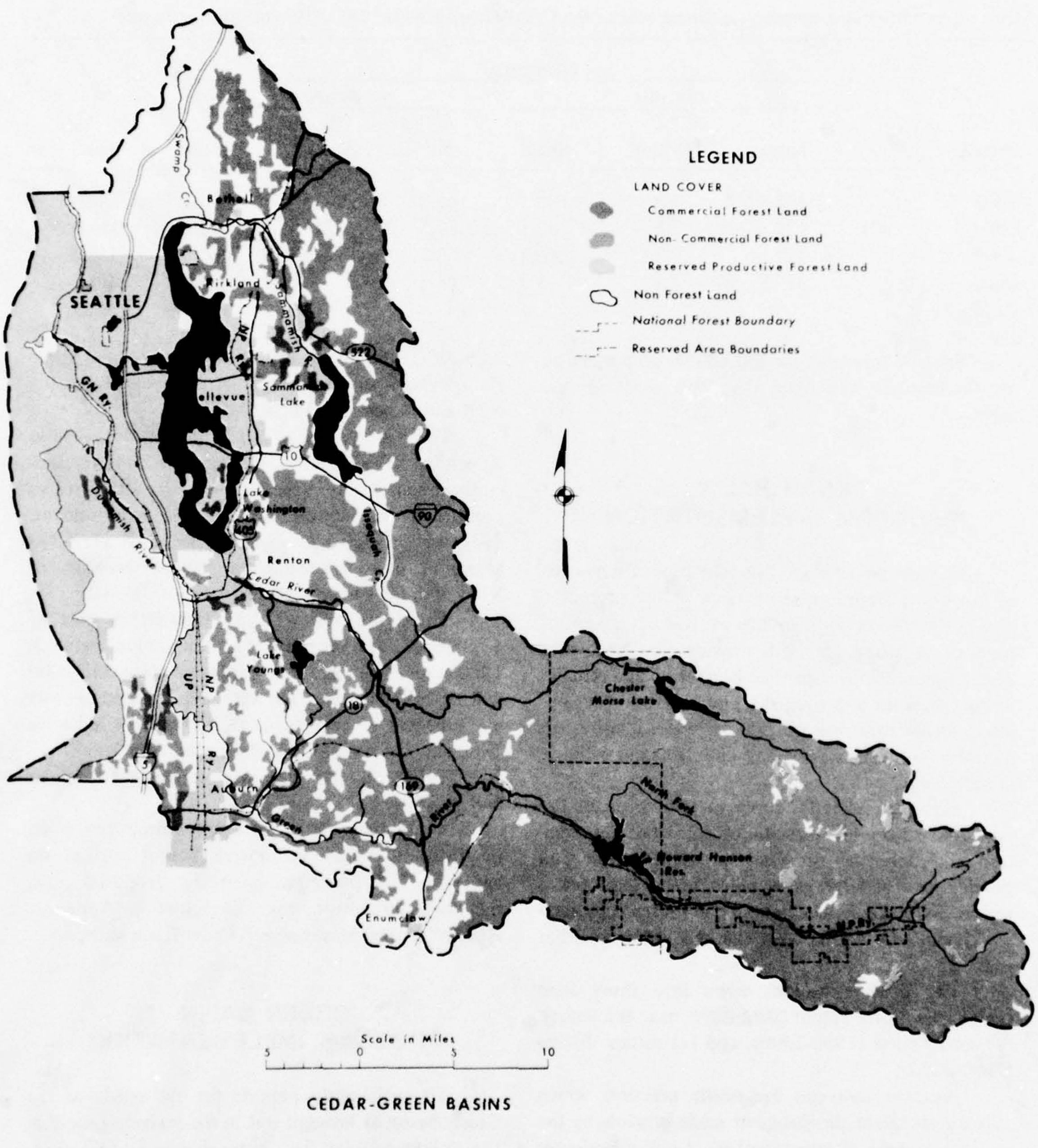


FIGURE 7-28. Forest lands in the Cedar-Green Basins

ment. Other measures provide for water quality and quantity control, recreation, and fish and wildlife development.

This plan includes programs and projects designed to accomplish specific objectives of conservation and development. They provide for the full development of lands expected to remain in cropland by 2020. Approximately half of the present cropland will remain by 2020, with the rest going to other uses.

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000). and (c) distant future (2000-2020).

Program measures are on-site practices which take advantage of development made possible by the structural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management, and irrigation development. Total cost of the early action period is $15,064,000. No early action projects are planned for this basin.

One project with an installation cost of $1,700,000 is proposed for the period between 1980 and 2000; and one project costing $100,000 will be installed after the year 2000. Program costs are expected to be $20,980,000 for the 1980-2000 period and $21,136,000 for the 2000-2020 period. Total cost of the plan is anticipated to be $58,980,000.

A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, Watershed Management, Green Basin section.

MINERALS

The locations of the known mineral deposits in the Basins are shown in Figure 7-29. The open circles on the map indicates properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

CEDAR BASIN

The Cedar Basin is one of the most important sand and gravel and clay producing areas in the entire Puget Sound Area. Other commodities that are being produced or have been produced are stone, silica, and coal. Although a few metallic mineral claims have been staked in the extreme eastern part of the basin, no production has been recorded.

Sand and Gravel

Good sand and gravel deposits are in short supply. This area is undergoing an urban expansion that is moving eastward from Seattle and the several communities on the east side of Lake Washington. As residential development moves eastward, it is overrunning potential gravel-producing areas to the extent that the remaining high-quality deposits are almost entirely east of Lake Sammamish and southeast of Renton.

Nine pits are currently producing material for aggregate, crushed rock, and fill material, but no statistics on total production are available for publication. Sand and gravel production is not meeting the current (1966) demand, and it appears that this situation will worsen because of the above-mentioned expanding urbanization. Most of the western part of the drainage system is blanketed by glacial outwash.

Stone

Three basalt quarries and one granite quarry are known. At the present (1966), only one quarry, the Sunset basalt quarry, is operating in the area. The others have been closed for one reason or another, not the least of which has been adverse zoning restrictions.

No stone production figures are available for publication. Although there are probably adequate reserves available under normal conditions, the urbanization of the area and the zoning restrictions prevent the area from producing enough stone to meet its own demands.

Silica

Four silica properties have a record of pro-

duction. At present (1966), only one property is being actively worked–the Cavanaugh molding sand pit. This pit has a long record of continuous production, but production figures are not available for publication, nor is there any estimate of reserves for the Cavanaugh pit or the Basin as a whole. The location of the Cavanaugh pit along the valley wall is such that it probably will not be affected by zoning in the immediate future.

Clay

Seven common clay pits, four refractory clay pits, and three special clay pits occur. Two common clay pits, the Newcastle and Renton, are currently (1966) being operated. One refractory clay pit is currently producing, and although neither of the bloating clay deposits is operating, one of them, the Cedar Mountain property, is being actively developed. Many of the clay pits that have produced in the past are inactive at present, but they could be reactivated at any time.

Clay production figures are not available for publication, and there is no estimate of reserves.

Coal

Coal has been one of the important resources contributing to the development of the Cedar Basin. Coal was first mined in the area near Renton in 1853. There are five coal areas (Fig. 7-29), but none of them are producing today.

The most extensive coalbeds of the area are in the Newcastle-Grand Ridge area, where the coalbeds occur in sedimentary rocks of the Renton Formation. The structure is fairly simple–the beds trend about east-west and pitch northward. The coal was first discovered near Issaquah in 1863. From the date of discovery to 1961, about 13 million tons of coal was produced. Reserves for the Newcastle-Grand Ridge coal area are estimated at 310 million tons.

Coal in the Renton area occurs in the Renton Formation. The coal seams pitch rather gently except in the southern part of the field, where the pitch reaches 65. About 4 million tons of coal was mined in this area from 1852 to 1961. Reserves are estimated at about 50 million tons.

The Cedar Mountain coal area is about 4 miles southeast of Renton. The coal seams occur in the Renton Formation, but no correlation with the Renton area coal measures has ever been made. Production from the Cedar Mountain area has amounted to about 4 million tons, and reserves are estimated to be about 67 million tons.

Coal in the Tiger Mountain area occurs in sedimentary beds of the Puget Group. The stratigraphic relations to other coal seams in King County are unknown. About 50,000 tons of coal has been mined from the area, and reserves are estimated to be about 9 million tons.

The Taylor coal beds are contained in sedimentary rocks of the Puget Group and are cut by several dikes and sills. Throughout the field, most of the coalbeds pitch about 70°. Incomplete production figures indicate that at least 640,000 tons of coal was taken from the area during its period of activity, and there are an estimated 19 million tons of reserves.

Peat

Seventeen peat bogs, covering 1,703 acres, have been investigated in detail. Eight of the bogs investigated contain sphagnum peat.

Two bogs are in commercial production, but no statistics on production are available for publication. Reserves appear to be adequate for the area's needs.

Diatomite

The McAleer Lake diatomite deposit, the only occurrence, is a bed 4 feet thick and is said to cover several acres. No other information is available concerning the deposit.

Copper and Gold

There are two copper properties and three gold claims, none of which have produced.

GREEN BASIN

The Green Basin is the source of more coal and stone than any other basin in the Puget Sound Area. Other commodities produced in quantity are clay, silica, peat, and sand and gravel. A small amount of quicksilver has been produced from the area, and arsenic and iron deposits also occur. Two mineral springs are known. (Note Fig. 7-29 for map showing mineral resources for the Green Basin.)

Coal

The first mining of coal in the Green River district began about 1882, and production has been continuous ever since. Peak production from the area was in 1903, when over 900,000 tons of coal was produced. Output has declined steadily since then, and in 1964, only about 60,000 tons was produced. Total production is estimated at a little more than 25

million tons. Reserves are estimated in excess of 357 million tons.

Sand and Gravel

Three of the four sand and gravel operators obtain their aggregate from glacial outwash material. The fourth operator obtains part of his aggregate from the Stuck River. The deposits in this area, as in the Snohomish and Cedar Basins, are slowly being made useless by urban expansion, but at a less rapid rate. About 50 pits in the area have produced sand and gravel for fill, aggregate, and crushed rock. No estimate of total production or potential reserves is available.

Clay

Twenty-one deposits of clay–12 common and 9 refractory–have a record of production. Of these, only three–two common and one refractory–are currently in operation. Eight additional refractory clay deposits are known but have not been developed. As in the Cedar Basin, the history of clay production in the Green Basin indicates that almost any pit that is inactive now could be reactivated in a matter of days, excepting those pits that have been covered by real estate development.

Although the clay reserves in the area appear to be large, no exact estimate of their size is available. Production is estimated to total in excess of 500,000 tons of clay.

Silica

Silica deposits have been formed by deep thorough weathering of arkosic sandstones of the Puget Group. The feldspar grains have been altered to clay, but the quartz grains have remained unchanged. The mixture of quartz grains and clay is washed, removing the clay and leaving a high silica sand residue.

Four silica deposits are known, but only one is currently producing. The deposit, operated by Smith Bros. Silica Sand Co., Inc., produces sand for manufacturing amber glass.

No production statistics or reserves estimates of silica for the area are available for publication.

Stone

Probably more stone is produced from this Basin than fr m any other basin in the Puget Sound Area. Five quarries are in the area; three are intermittently active, and the other two have been operating continuously for many years producing rubble, landscape, rock, and crushed rock. The two operating quarries are both in basalt and are near the southern boundary of Seattle. One of the other quarries, at Veazey Station near Enumclaw, is an excellent source of riprap because of the columnar nature of the rock.

No production figures are available for publication. The Black River quarry appears to have adequate reserves for several years of production, but reserves at the Riverton quarry are nearly depleted. The other quarries apparently have sufficient reserves for many years at the present rate of production.

Peat

Twenty-one peat bogs, covering 1,200 acres, have been investigated. Five of these bogs contain sphagnum peat, and seven of them are currently (1966) producing. Reserves are adequate for many years to come at the present rate of consumption.

Mercury

Mercury has been produced from one property–the Royal Reward (Fig. 7-29, No. 97)–near Black Diamond. The ore deposit consists of cinnabar-filled fractures in sandstone, carbonaceous shale, and andesite. Gangue minerals are realgar and orpiment. It is estimated that about 20 flasks of quicksilver were produced during the time the property was active in 1957 and 1958.

Oil and Gas

The sandstone of the Puget group offers excellent reservoir rock for the accumulation of oil and gas, and many of the shale beds might well be considered as source rocks. In spite of apparently favorable conditions for the occurrence of oil and gas, none has been found in commercial quantity. Oil shows have been restricted to fluorescence in cores, and gas shows have all been low volume. Thirteen test wells have been drilled, the deepest of which had a total depth of 6,023 feet.

Mineral Springs, Arsenic, and Iron

Two undeveloped mineral springs are in the drainage system. One iron and two arsenic deposits are in the area, but none of them have had production.

MINERAL PROPERTIES IN CEDAR-GREEN BASINS*

Explanation for Figure 7-29

Metallic Minerals
(with production or reserves data where available)

Arsenic (2 properties)

Copper (2 properties)

Gold (3 properties)

Iron (1 property)

Mercury (2 properties)

97	–	Royal Reward (prod.–20 flasks)

Nonmetallic Minerals
(with reserves data where available)

Coal (reserves–812 million tons)

Common clay (19 properties)

60	–	Abramson
69	–	Bayne
60A	–	Builders Brick
61	–	Builders Brick
65	–	Builders Brick
67	–	Durham Coal
59	–	Duwamish River
66	–	Empire Brick and Tile Co.
58	–	Hill Brick Co.
44	–	Hill Brick Co.
62	–	Lone Star
48	–	Newcastle
43	–	Northwest Haydite
63	–	Northwest Pottery Co.
50	–	Renton
64	–	Seattle Brick & Tile Co.
45	–	Stillwell
52	–	Taylor
46	–	Washington Pottery Co.

Diatomite (1 property)

Mineral Water (2 springs)

Refractory clay (21 properties)

73	–	Adderson
72	–	Alcorn
78	–	Auburn
79	–	Blum
76	–	Brooks
68	–	Gladding McBean
49	–	Harris
47	–	Issaquah
71	–	Johnson Coal Co.
70	–	Kummer
75	–	Smith Bros.
57	–	Taylor

Silica (9 properties)

74	–	Alcorn
77	–	Brooks
54	–	Cavanough
78	–	Gladding McBean
52A	–	Renton Junction
51	–	Renton Mine
77	–	Smith Bros.
53	–	Wilde

Special clay (3 properties)

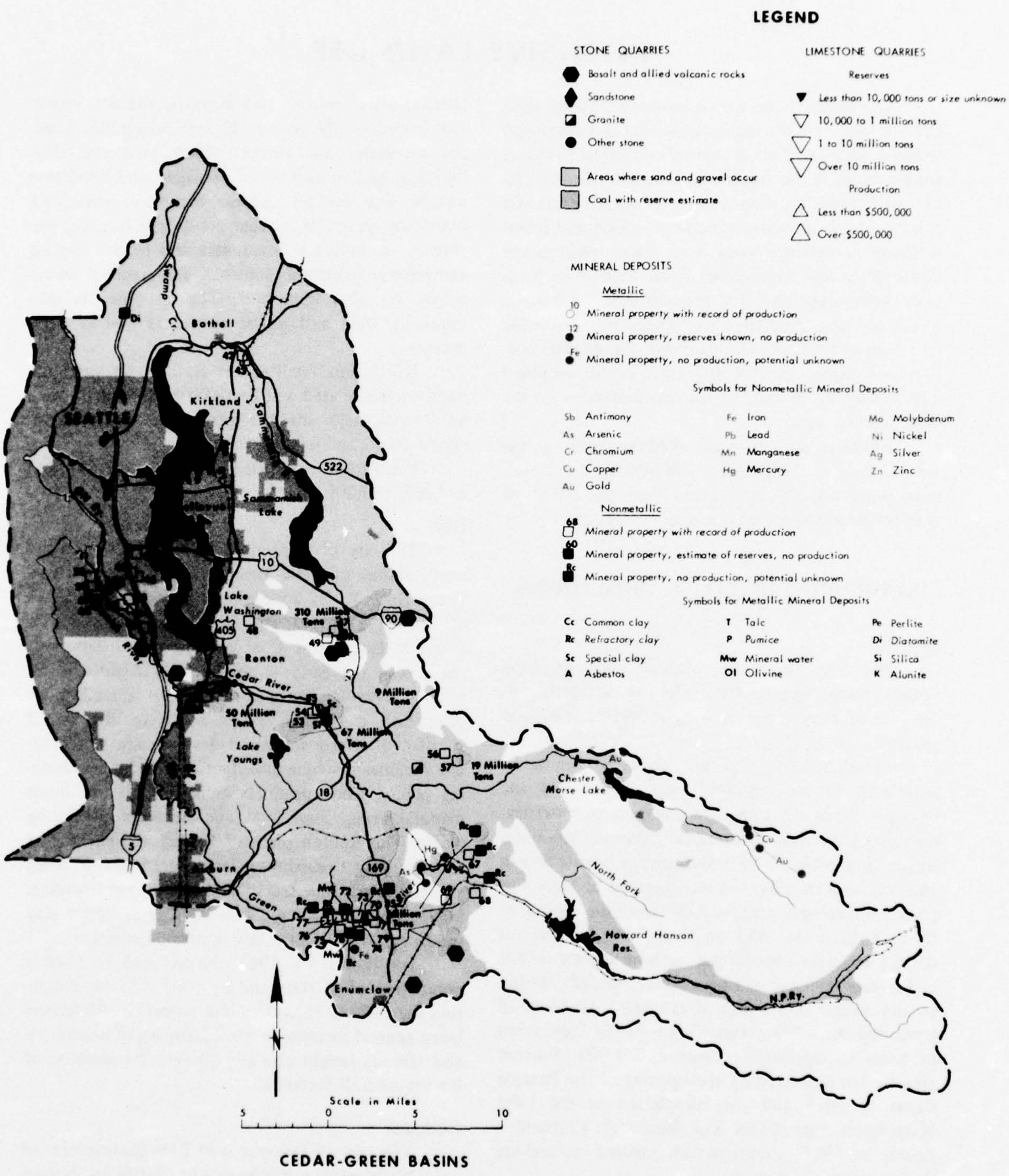
55	–	Cedar Mountain
42	–	Northwest Haydite

Stone Deposits

Basalt (7 properties)

Granite (1 property)

*Some properties not plotted on map because of poor description of location and/or lack of space.



CEDAR-GREEN BASINS

MINERALS

FIGURE 7-29. Mineral resources in the Cedar-Green Basins

INTENSIVE LAND USE

The Cedar-Green Basins cover over half of King County including the highly urbanized and developed western portions. Timber and related forest products are produced in the upper reaches of the Basins. The city of Seattle, the Snoqualmie National Forest and private timber companies maintain substantial forest areas on a sustained yield basis. Farm lands in the Cedar-Green and Sammamish River Valleys are gradually being developed for residential and industrial use. Remaining croplands are located mainly on the rich alluvial lowlands. Lands above the alluvial bottoms are highly variable and are used for cropland and woodland. Woodland use predominates as the elevation increases.

Intensive land uses are predominantly in the western half of the Basins where Seattle, the State's most populous city, is located. There are a total of twenty-one incorporated places in the Basins.

INCORPORATED CITIES AND TOWNS

Seattle

The city of Seattle, county seat of King County, is the largest city of the Pacific Northwest, the hub of a metropolitan area of over one million persons.

Seattle's scenic location places her on seven hills with Elliott Bay on Puget Sound and the Olympic Mountain Range to the west and twenty-mile long Lake Washington and the Cascade Mountain Range to the east. First settlement in Seattle was in 1851-52, and the city was incorporated in 1869, but population remained below 3,600 until the coming of the railroads after 1884. In June 1889, the business district was wiped out by fire but immediately rebuilt and a year later population was over 40,000. Within twenty years, as a result of the 1897 Alaska Gold Rush and the 1909 Alaska-Yukon-Pacific Exposition in Seattle, population exceeded 235,000. Further growth was generated by the opening of the Panama Canal in 1915 and the completion of the Lake Washington Ship Canal and Hiram M. Chittenden Locks in 1917, events which assisted in making Seattle a major U.S. port.

Seattle has many assets; it is the gateway to the shortest route of travel from continental United States to the Orient, its harbor can accommodate most shipping demands, it has four transcontinental railroad terminals and two airports, and it is important commercially, financially, and industrially. Leading industries are aircraft, food products, shipbuilding, lumber and wood products, and fabricated metals; but textiles, paper, furniture, chemicals, petroleum products, leather goods and luggage, machinery, including railroad cars and trucks, heating equipment, electronic controls, and medical instruments are also important. The city has its own municipal light and power system as well as water system.

Recreation facilites for Seattle are predominantly water-related with Lake Washington and Green Lake being major sites for spectator as well as active sports events and/or shows.

Population in Seattle in 1950 was 467,591, and in 1967, 580,000.

Renton

The city of Renton is in King County on the south shores of Lake Washington at the mouth of Green River Valley approximately twelve miles south of Seattle. The area was first settled in 1853 as a donation land claim. Coal was discovered there that same year and early industries, in addition to coal mining, were logging and sawmilling. A fresh-water port with a through water route to the Sound stimulated diverse industrial development which today includes machine manufacturing and metal working plants, wood products industries, clay products manufacturing, and food and beverage processing plants. The Renton plant of Boeing; the Pacific Car and Foundry Company, a large steel foundry which also builds tractors, trucks, and busses; and Gladding, McBean and Company, which molds and fires clay products, are within the city limits of Renton.

Incorporated in 1901, the city had, by 1940, a population of 16,039, and by 1967, 23,066. Projection for 1970 is 35,000 with principal growth factors being general increase in manufacturing of machinery and railroad freight cars and continued expansion of Boeing Aircraft facilities.

Bellevue

The city of Bellevue is in King County east of Lake Washington and connects to Seattle on its west by two four-lane floating bridges. Originally a small trading center for berry farmers and vineyardists, Bellevue was incorporated in 1953 and is now a fast-growing suburban residential community.

Factors which have contributed to the growth expansion include the completion of Lake Washington Floating Bridge in 1941; the removal of bridge tolls in 1949; the opening of Evergreen Point Floating Bridge in 1963; and the general post-war continuing growth of the Seattle Metropolitan area. Bellevue's population in 1950 was 2,500; by 1960, it had increased to 12,366; and in 1967 was 22,000.

A third Lake Washington floating bridge is presently being planned by the State to serve the general area.

Mercer Island City

The city of Mercer Island on Mercer Island, which is located in Lake Washington between Seattle and Bellevue and connected to them by the floating bridge system, is a rapidly growing residential suburb which was incorporated in 1960 with 12,693 residents; the 1967 population was 16,500.

Auburn

The city of Auburn is in south King County between Seattle and Tacoma. Settled by pioneers in 1855, the area was platted in 1886 as Slaughter and incorporated as Auburn in 1914. The city is the freight terminal for Northern Pacific Railroad and a stop on three other major transcontinental lines, making railroads the city's major industry. Other industries include wood and food products and Federal Aviation Agency Air Traffic Control Center. The population of Auburn in 1950 was 6,497 and in 1967, it was 17,092, considerably ahead of predictions. The new Boeing plant, taking over part of an old army supply depot, is a chief factor in recent growth spurt.

Kent

The city of Kent, located in the Green River Valley about 15 miles south of Seattle, was first settled in 1853 and incorporated in 1890. It remains a shipping, canning, and processing center for the berry, dairy, and truck garden crops of the Valley snapbeans and cabbage being the two largest crops. Kent's population in 1950 was 3,278 and in 1967, 14,009, a considerable amount of growth from Seattle spillover. It is rapidly becoming an industrial center as well, with recent growth keyed to establishment of the Boeing Space Center.

Kirkland

The city of Kirkland is in King County on the east shore of Lake Washington north of Bellevue and two miles from Seattle via the Evergreen Floating Bridge. The site was originally settled in 1872 and the town founded in 1887 by Peter Kirk, who planned the city as a manufacturing center and operated an iron and steel foundry there until 1891. Incorporated in 1905, Kirkland is today chiefly a market center for the surrounding area and a suburban residential city for Seattle workers. From a 1950 population of 4,713, the city had grown in 1967 to 7,500, a substantial increase though less sizable than other area towns. In April 1968 the city of Houghton was consolidated with Kirkland adding 3,630 and giving Kirkland a total 1967 population of 11,130.

Redmond

The city of Redmond, located in King County east of Seattle and Lake Washington, has grown from its 573 residents of 1950, to 6,113 residents in 1967. Incorporated in 1912, the city has evolved from a town whose economy was derived from logging sawmills and the products of the surrounding farm and dairy country to a town whose population is economically linked to Seattle and its suburbs. Also in 1962, Redmond annexed an industrial park area between its boundaries and Bellevue.

Bothell

The city of Bothell, situated on the Sammamish River near the northern end of Lake Washington, was settled by the Bothell family in 1886 and incorporated in 1909. Today it is both a farm trading center and residential suburb of Seattle with a 1967 population of 4,102, a 3,000 increase over the 1950 population.

Medina

The city of Medina is adjacent to Bellevue on the east shore of Lake Washington. Although platted in 1914, Medina was not incorporated until 1955 and it today chiefly a residential suburb or Seattle with a 1967 population of 3,272.

Issaquah

The city of Issaquah is in the Sammamish Valley at the southeast end of Lake Sammamish. Incorporated as Gilman in 1892, and as Issaquah in 1899, the town was originally founded primarily for coal mining and lumbering, but today serves as a trading center for the valley and a market for the area's poultry and dairy products. A 1950 population

of 950 had swelled to 3,526 by 1967. This community is also experiencing growth based on "the flight to suburbia."

Des Moines

The city of Des Moines, located on Puget Sound south of Seattle, was settled first in the 1870's developed in 1889, but not incorporated until 1959. A limited amount of poultry raising and berry cultivation exists. Des Moines had a 1960 population of 1,987 and a 1967 population of 3,665.

Enumclaw

The city of Enumclaw, located in the Cascade foothills east of Tacoma, is a gateway to the Chinook and Naches Passes and the recreation areas of Mt. Rainier and Snoqualmie National Forest. Enumclaw was incorporated in 1913 and lumber and dairy industry and tourist and farm trade make up the chief sources of income. The city's population has not increased as greatly as most other cities in King County. The 1950 population was 2,789 and the 1967 population 3,925.

Tukwila

The city of Tukwila is south of Seattle on the Duwamish River. Settled in 1850 and incorporated in 1908, Tukwila has been a residential suburb but is currently attracting industry to the 375-acre industrial site opened in 1961. The population in 1950 was 800, and by 1967, 2,325.

Other incorporated places are:

Clyde Hill, incorporated in 1953, with a 1967 population of 2,839.

Black Diamond, incorporated in 1959, with a 1967 population of 1,034.

Algona, incorporated in 1955, with a 1967 population of 1,286.

Pacific, incorporated in 1909, with a 1967 population of 1,818.

Normandy Park, incorporated in 1953, with a 1967 population of 3,870.

Beaux Arts, incorporated in 1953, with a 1967 population of 375.

Mercer Island Town, incorporated in 1960, with a 1967 population of 825.

Unincorporated places include Eastgate, Hollywood, Woodinville, Preston, Maple Valley, Palmer, and Cedar Falls.

TRANSPORTATION

Rail–The Cedar-Green Basins is served by the Great Northern, Northern Pacific and the Milwaukie Railroads.

Highways–Major highways are U.S. Highway 99 (Interstate 5) running from south to north, U.S. 10 (Interstate 90) running east and west, and State Highway 516 running east and west. Numerous secondary State highways, city highways and county highways cover the western portion of the basin

Airways–Seattle-Tacoma and Boeing airfields provide commercial air facilities for the basins, with a number of small airfields providing local needs.

Navigation–The port of Seattle provides the major port for the Study Area. Commercial navigation can travel 5 miles up the Duwamish River and as far as Lake Washington via the Hiram M. Chittenden Locks.

LAND USE CHARACTERISTICS

There are 704,168 acres of land within the Cedar-Green Basins and 38,838 acres of inland water. Table 7-31 contains the figures showing the various amounts of major land use acreages within the Basins.

Figures 7-26 A & B portrays the land use for the Cedar-Green River Basins. The map amply shows that this area is the population center, and the major location of intensive land use for the entire Study Area.

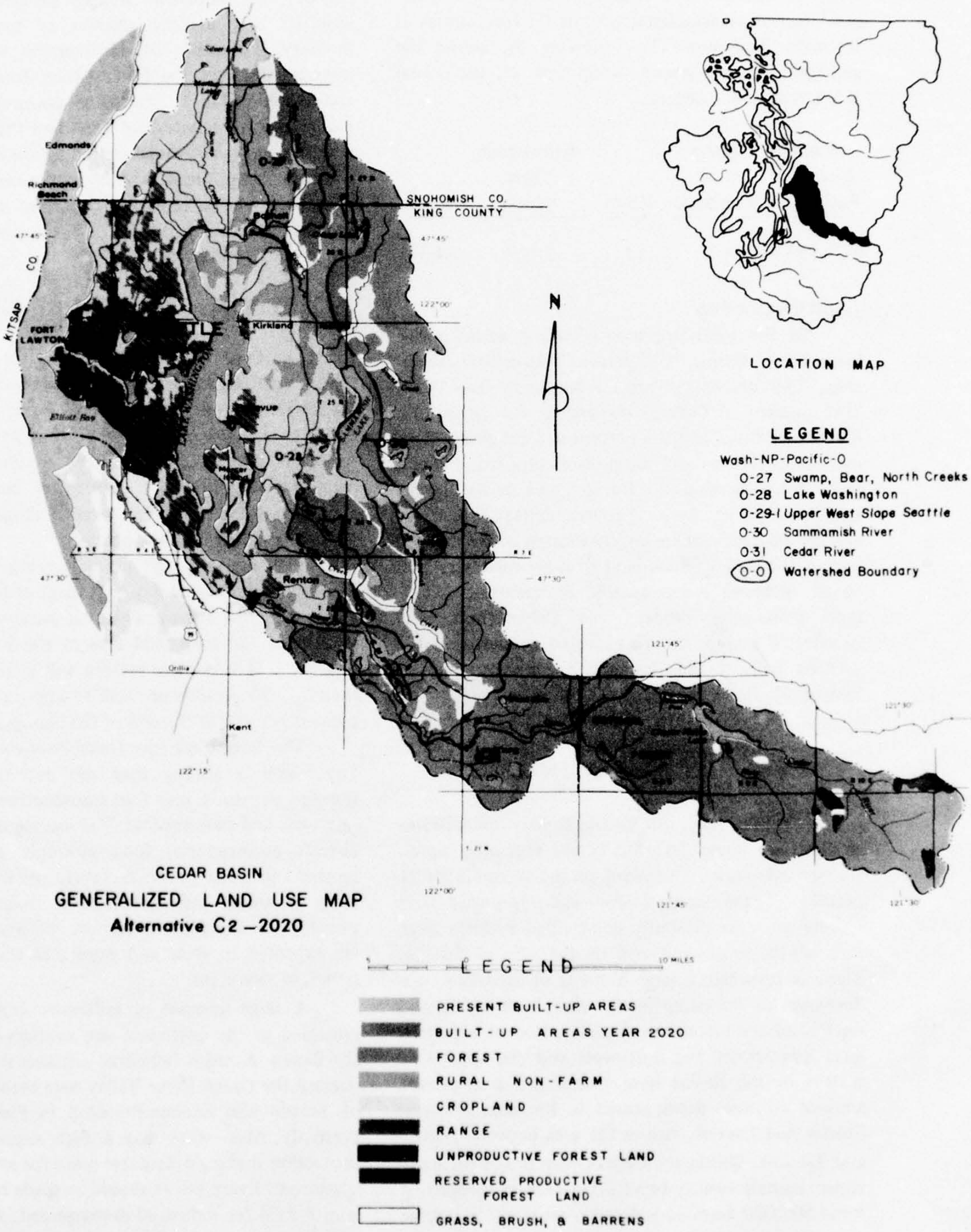
Intensive Land Use

At the present time (1967) intensive land uses occupy some 166,401 acres or 23.6 percent of the Basins' land area, which is the greatest amount of intensive land use within any basin. Although the intensive land use is extensive in the Seattle metropolitan area and along the Sound, a few intensive uses will be found at scattered locations throughout the Basins. The following list contains the land use figures for the intensive land use subgroups.

Railroads	Roadways	Airports	Urban (Built-up)	Total
3,051	9,297	2,503	151,550	166,401

Rural Nonagricultural

Many of the land uses classified within the



Edmonds
Richmond Beach
SNOHOMISH CO.
KING COUNTY
KITSAP CO.
FORT LAWTON
Elliott Bay
Kirkland
Renton
Orillia
Kent
O-27
O-28
N
LOCATION MAP
LEGEND
Wash-NP-Pacific-O
O-27 Swamp, Bear, North Creeks
O-28 Lake Washington
O-29-I Upper West Slope Seattle
O-30 Sammamish River
O-31 Cedar River
O-O Watershed Boundary
CEDAR BASIN
GENERALIZED LAND USE MAP
Alternative C2 – 2020
LEGEND
10 MILES
PRESENT BUILT-UP AREAS
BUILT-UP AREAS YEAR 2020
FOREST
RURAL NON-FARM
CROPLAND
RANGE
UNPRODUCTIVE FOREST LAND
RESERVED PRODUCTIVE FOREST LAND
GRASS, BRUSH, & BARRENS

FIGURE 7-30A

Rural Nonagricultural category are similar in character and often associated with or the forerunners of intensive land use. The following list shows the acreages in the several subgroups of the Rural Nonagricultural category.

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm years)	Total
29,952	429	537	3,427	34,345

Land Ownership

Of the total land area (704,168 acres) in the Cedar-Green Basins, 53.2 percent is in private ownership, 23.0 percent in private corporate ownership, 10.2 percent in Federal ownership, 4.1 percent in State ownership, and 9.5 percent in local government ownership. The bulk of the private corporate, Federal and State ownerships are forested areas in the Basins. Land areas owned by local governments (city, county and special districts) are largely located in the western half of the Basins. These land areas are mainly related to an intensive use consisting of streets, facilities, local parks and similar areas. Other (nonforest) private ownerships are also located primarily in the western half of the Basins and consist mainly of intensively used land areas.

TRENDS AND POTENTIALS

Intensive land use in the Cedar-Green Basins amounts to some 167,000 acres. This area equals slightly over seven (7) townships and accounts for 21 percent of the total Basins' area. Intensive land requirements are presently being filled within a large area north, south and east of the city of Seattle. There is presently a large amount of suburban type development occurring in this area, both within and outside of the incorporated places. Recent industrial developments in the northwest and the southwest sectors of the Basins have encouraged a significant amount of new development in the area between Seattle and Everett, and in the area between Seattle and Tacoma. Within the Cedar-Green Basins there are approximately twenty-two (22) townships comprising some 507,000 acres considered most likely to receive pressure for intensive development. These townships are located in the western third of the Basins and include the present Seattle urban area—the city of Seattle, the numerous smaller incorporated communities and a large amount of unincorporated territory. Potential for development of additional intensive uses in the Cedar-Green Basins is highly considerable due to the large amount of acreage available in the hinterland areas and the growth and development pressures generated by the Seattle urban complex. A significant amount of the existing agricultural land will be replaced by various intensive land uses in the future, just as it has in the immediate past.

PRESENT AND FUTURE NEEDS

The Cedar-Green River Basins are the population, industrial, commercial and residential centers of the Puget Sound Area. In 1967, over half of the entire population of the Puget Sound Area resided in the Cedar-Green Basins. Present trends point to a continued expansion in population, industry, new commercial facilities, and a wide range of various types of residential developments.

The intensive land use within the Cedar-Green Basins presently occupies 21 percent of the total land area within the Basins. This will increase to over 43 percent of the total land area of the Basins by the year 2020. The density pattern will increase from its present 5.85 persons per acre to approximately 16.0 persons per acre at the end of the plan period.

The Basins are the transportation hub of the area, with a harbor that can accomodate most shipping demands, plus four transcontinental railroad terminals and two airports. The leading industries are aircraft construction, food products, shipbuilding, lumber and wood products, fabricated metals, plus a host of other industries. These industries, with possibly the exception of lumber and wood products, are expected to grow and expand as the population grows, or vice versa.

A large amount of industrial development is projected in the northwest and southwest sectors of the Basins. A major industrial corridor is expected to occupy the Green River Valley area between the city of Seattle and Sumner-Puyallup in Pierce County. Presently, this valley has a high degree of flood protection making a desirable place for new industrial expansion. Every effort should be made to assure this land is held for industrial development. Any residential development should be relegated to the hillsides surrounding the river valley. Also, an effort should be made to provide a recreational corridor along the

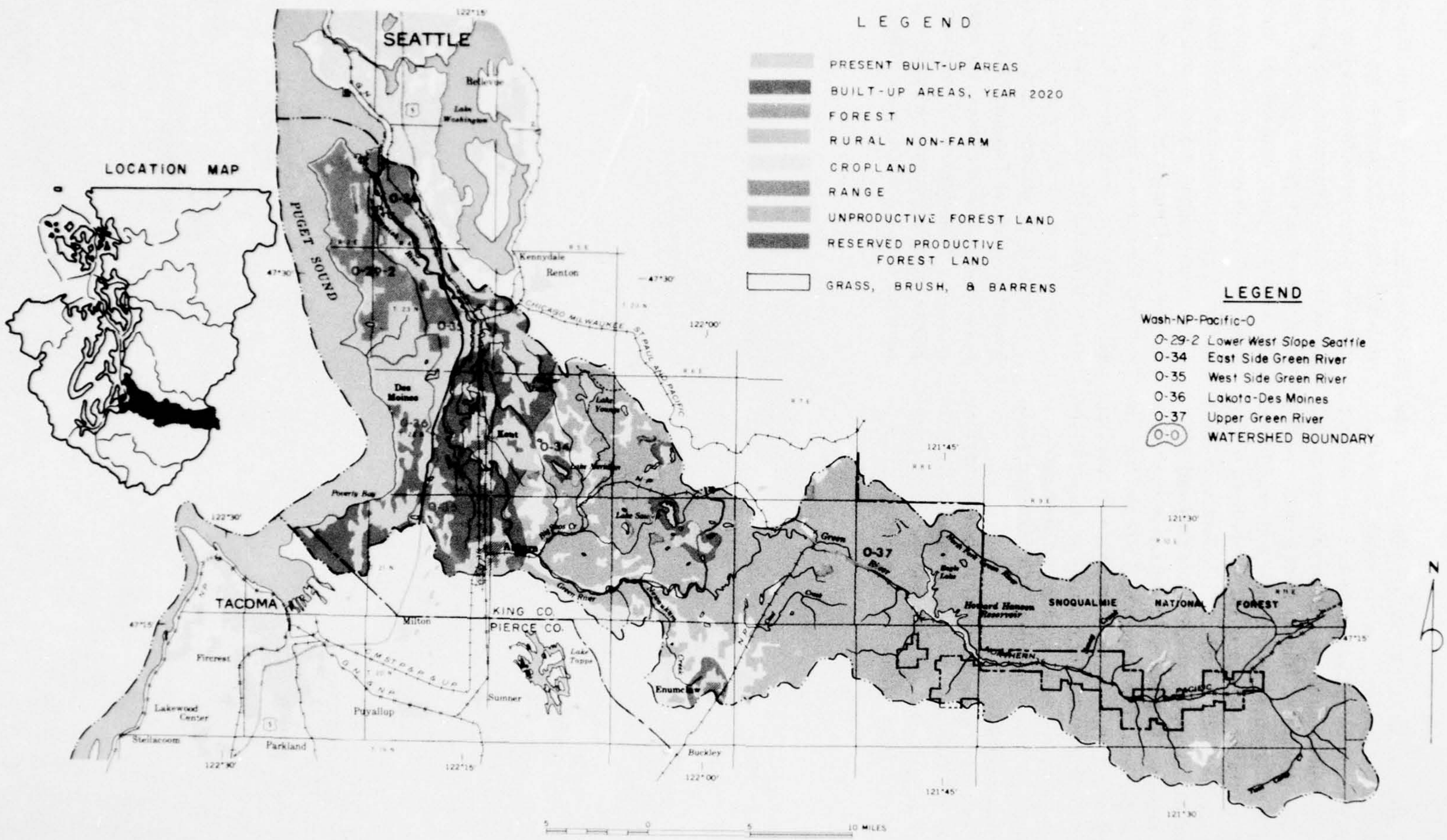


FIGURE 7-30B

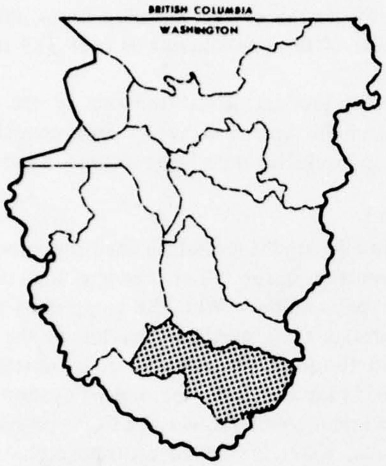
GREEN BASIN
GENERALIZED LAND USE MAP
Alternative C2 –2020

entire river as it travels through the valley. The industrial development in the river valley has replaced a large amount of agriculture lands in the past, and this trend will continue through the planning period.

The Howard A. Hanson Dam project, coupled with the soil drainage projects now underway by the Soil Conservation Service in the Green River Valley above Auburn will provide a high degree of flood control to this upper portion of the river and valley, thus increasing its potential use as highly productive agricultural land. The Dam project will also increase recreation potentials in the River Basin. Proper land use controls must be forthcoming at the time the improvements are made in the upper river valley, so as to assure that this valley will remain open to agricultural pursuits.

Past investigations show that there are approximately 507,000 acres of land considered likely to receive pressure for intensive land use development by the year 2020. Without a cross-Sound bridge to Vashon Island it appears that at 16 persons per acre, an additional 65,000 acres of land will be needed to fulfill the demands for intensive land use. Thus, as in the other basins, a highly selective process of development should take place so that the least amount of conflict takes place between the various land uses. Figure 7-30 A and B portrays the generalized land use pattern (C_2) for the Cedar-Green Basins for the year 2020 which assumes a cross-Sound bridge. With this pattern an additional 56,500 acres of land will be required for intensive purposes by the year 2020, to accommodate a population to 3,619,900. The Cedar-Green River Basins will, by the year 2020, be the central portion of a large metropolitan area, the solid development of intensive land use from north of Everett to south of Tacoma. "Regional" or basin by basin coordination in planning and development must take place at all levels of government, and with the private sector to provide assurance that this area will continue to be a desirable place to live.

PUYALLUP BASIN



The Puyallup Basin, located in the central sector is the third largest Basin in the Puget Sound Area and includes the Tacoma metropolitan area. The greater portion of the drainage area is in Pierce County with a comparatively small area in King County. The total hydrologic area is 770,347 acres. The principal tributaries to the Puyallup River include the White River, Carbon River, and South Prairie Creek. Other small tributaries to the system include the Greenwater, Clearwater, and Mowich Rivers; Hylebos, Voight, and Chambers Creeks.

Population

The population of the Basin in 1967 was 349,800 persons. This population is primarily located in the Tacoma metropolitan area in the western portion of the Basin. Projections show that the population will grow to 449,800 by 1980, 721,000 by 2000 and 1,157,700 by the year 2020. The new growth will take place adjacent to the existing areas of development.

Land Use

The primary land use in the Puyallup Basin, as it is in all basins in the Puget Sound Study Area, is forests and associated land which cover over 78% of the total land in the Basin. The other two major uses, croplands and intensive or built-up land uses occupy 5% and 12%, respectively. Table 7-40 shows the tabulation of present land use within the Basin. Figure 7-31, the generalized land use map of the Puyallup Basin, portrays the land areas occupied by each of the major uses.

TABLE 7-40. Land use in Puyallup Basin (acres)[1]

Map No.	Watershed	Crop-land	Range-land	Total Forest[2]	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
7-1	White River	15,676	378	285,850	4,989	7,246	5,582	319,721
7-2	Carbon River	1,376	90	84,702	684	738	705	88,295
7-3	Puyallup River	11,856	1,135	133,749	8,072	14,011	2,008	170,831
7-4	South Prairie Creek	2,492	175	52,336	560	413	101	56,077
	Total Puyallup River	31,400	1,778	556,637	14,305	22,408	8,396	634,924
0-38	Hylesbos Creek	1,281	177	7,239	915	6,388	263	16,263
0-39	Wapato Creek	1,699	20	829	1,408	2,451	100	6,507
0-40	Fort Lewis-Tacoma	2,473	3,708	28,634	9,101	66,199	2,538	112,653
	Total Pacific Drainages	5,453	3,905	36,702	11,424	75,038	2,901	135,423
	Puyallup Basin	36,853	5,683	593,339	25,729	97,446	11,297	770,347

[1] *Unadjusted measurements, 1966, for Puget Sound Area Study.*

[2] Figures include nonforested land commonly associated with forest areas.

AGRICULTURE

PRESENT STATUS AND POTENTIAL

The Puyallup Basin is located largely in Pierce County, although ten percent of the Basin is located in southern King County.

The western half of this Basin has extensive alluvial flats and gravelly terraces graduating into a large area of rugged mountainous terrain, including Mount Rainier in the east.

Of the total land area of 759,050 acres in the Basin, those lands outside the national forests and parks have been mapped by a medium-intensity soil survey. Lands within the national forest and park boundaries have been mapped by a low-intensity soil survey suitable for reconnaissance use. Of the 454,209 acres mapped with the medium-intensity soil survey, nearly 284,000 acres are classified in Land Use Capability Classes II through VI.

These 284,000 acres of land have the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, and IV are suited for either cropland or urban uses, and Class VI has potential for urban developments.

The Puyallup River is one of the larger river systems in the Puget Sound Area. It drains an area of 992 square miles. The principal tributaries are the White River and the Carbon River. Coastal waters drain 212 square miles, and empty directly into Puget Sound. The Puyallup Basin as a whole drains 1,204 square miles of territory.

The Puyallup Basin provides the fifth largest valley system in the Puget Sound Area. The system includes many flood and drainage problem areas which require corrective measures before their potential can be attained. The lower flood plain contains about 27,000 acres of level or gently undulating bottom lands. South of Tacoma, the land becomes relatively level, and problems with winter flooding frequently occur. The eastern reaches of the Basin contain steep, mountainous valleys with turbulent streams.

Production

Farming and forestry are two of the main users of land in the Basin, and farming is still a very important part of its economy. In the last few years, specialty crops such as bulbs, flower plants, commercial shrubs, and herbs have superseded dairying as the most important product in the farming industry. Poultry, berry and vegetable production make up an important segment of the Puyallup Basin industry. Total value of farm production is over $13 million annually.

Forest products constitute one of the prime resources of the Area, with several large sawmills and wood pulp producing mills being located in the Basin.

Flooding

Climatic conditions induce one flood-producing season annually, in the fall or winter as the result of excessive precipitation. With the completion of the Mud Mountain Dam, overbank flooding by the White River and the lower Puyallup River is substantially eliminated. Flooding from the upper Puyallup River and from minor tributaries is still a major problem. In many areas, water is trapped by topographic detail until it can seep into the soil. Excessive rainfall causes similar flooding conditions, as well as swamping of the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV, Watershed Management. Principles and conditions discussed therein apply to the Puyallup Basin and need not be repeated here.

Watersheds

Seven watershed areas requiring solutions to problems or development to achieve potential productivity of the Basin are shown on the Land Use Map (Figure 7-31) and the Land Capability Map (Figure 7-32).

The White River watershed (7-1) along with the Puyallup River watershed (7-3) contain 75 percent of the cropland and 71 percent of the forest land in the Puyallup Basin. Of this forest land, almost 60 percent is in either Snoqualmie National Forest or Mount Rainier National Park. Agriculture will continue to be important in the White River watershed. In the Puyallup River watershed, it is likely that many acres of farm land will become urbanized. Both watersheds will continue to be important forest product and water resource areas for the Basin.

The Carbon River watershed (7-2) and South Prairie Creek watershed (7-4) are almost entirely

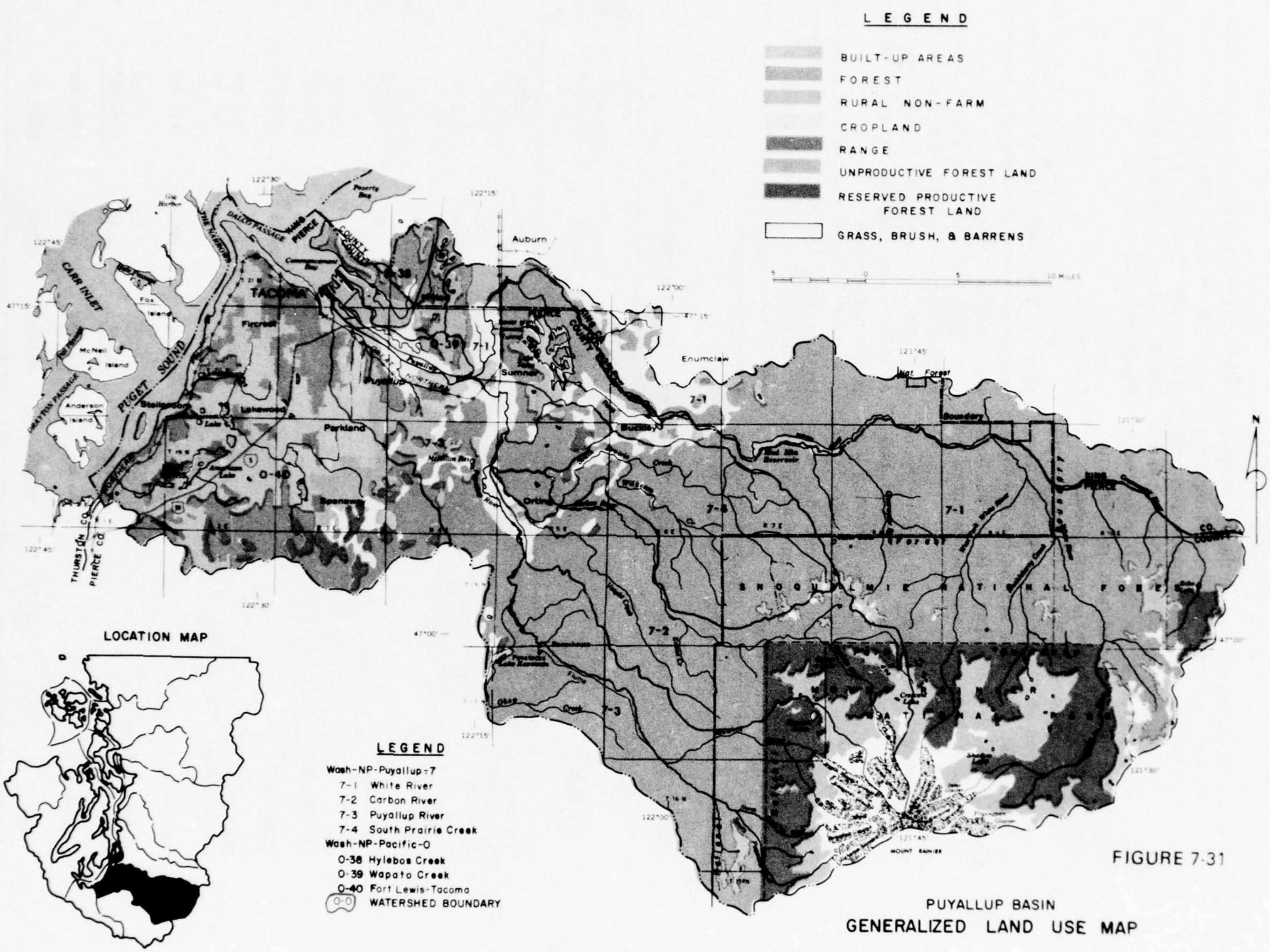


FIGURE 7-31

PUYALLUP BASIN
GENERALIZED LAND USE MAP

forested with a large percentage of the area being in Mount Rainier National Park and Snoqualmie National Forest. There is more emphasis upon cropland in the South Prairie Creek watershed than in the Carbon River watershed, but there is a very small amount of cropland or urbanization in either watershed. Potential use lies largely in forest products.

Hylebos Creek watershed (0-38) and Wapato Creek watershed (0-39) discharge directly into Commencement Bay. They have little cropland or forest land. Urbanization is important at the present time, and is likely to be the potential development of the future.

Fort Lewis-Tacoma watershed (0-40) contains the cities of Tacoma, Steilacoom, Lakewood, Parkland, Spanaway, and a considerable portion of Fort Lewis. Over 75 percent of the urbanized area of the Basin is in this watershed. Potential use would seem to be further urbanization and continued use of Fort Lewis as a military installation.

Many of the farm lands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions are summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the Puyallup Basin is shown in Table 7-40. The following tables are to indicate the potential development possible within acceptable land use standards.

Table 7-41 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-42 shows the number of acres in each capability class, subclass, and unit, by watersheds, in the Puyallup Basin. This table can be used with the description of capability units to estimate the potential for development.

TABLE 7-41. Distribution and value of production by crops in Puyallup Basin

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	135	199	.54	9,603	.16
Field crops	76	112	.30	33,437	.57
Vegetables	1,469	2,164	5.87	464,413	7.85
Berries	852	1,256	3.41	1,292,785	21.86
Nursery products	740	1,091	2.96	1,903,009	32.18
Cropland not used	1,968	2,901	7.87	--	--
Sub-Total	5,240	7,723	20.95	3,703,247	62.62
Hay	5,746	8,468	22.98	396,921	6.71
Hay aftermath	--	--	--	234,993	3.97
Sub-Total	5,746	8,468	22.98	631,914	10.68
Silage (grass)	1,255	1,849	5.02	122,505	2.07
Grass aftermath	--	--	--	51,361	.87
Sub-Total	1,255	1,849	5.02	173,866	2.94
Silage (corn) fodder	219	322	.87	21,332	.36
Pasture (cropland)	12,547	18,491	50.18	1,383,987	23.40
Sub-Total	19,767	29,130	79.05	2,211,099	37.38
Total	25,007	36,853	100.00	5,914,346	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.

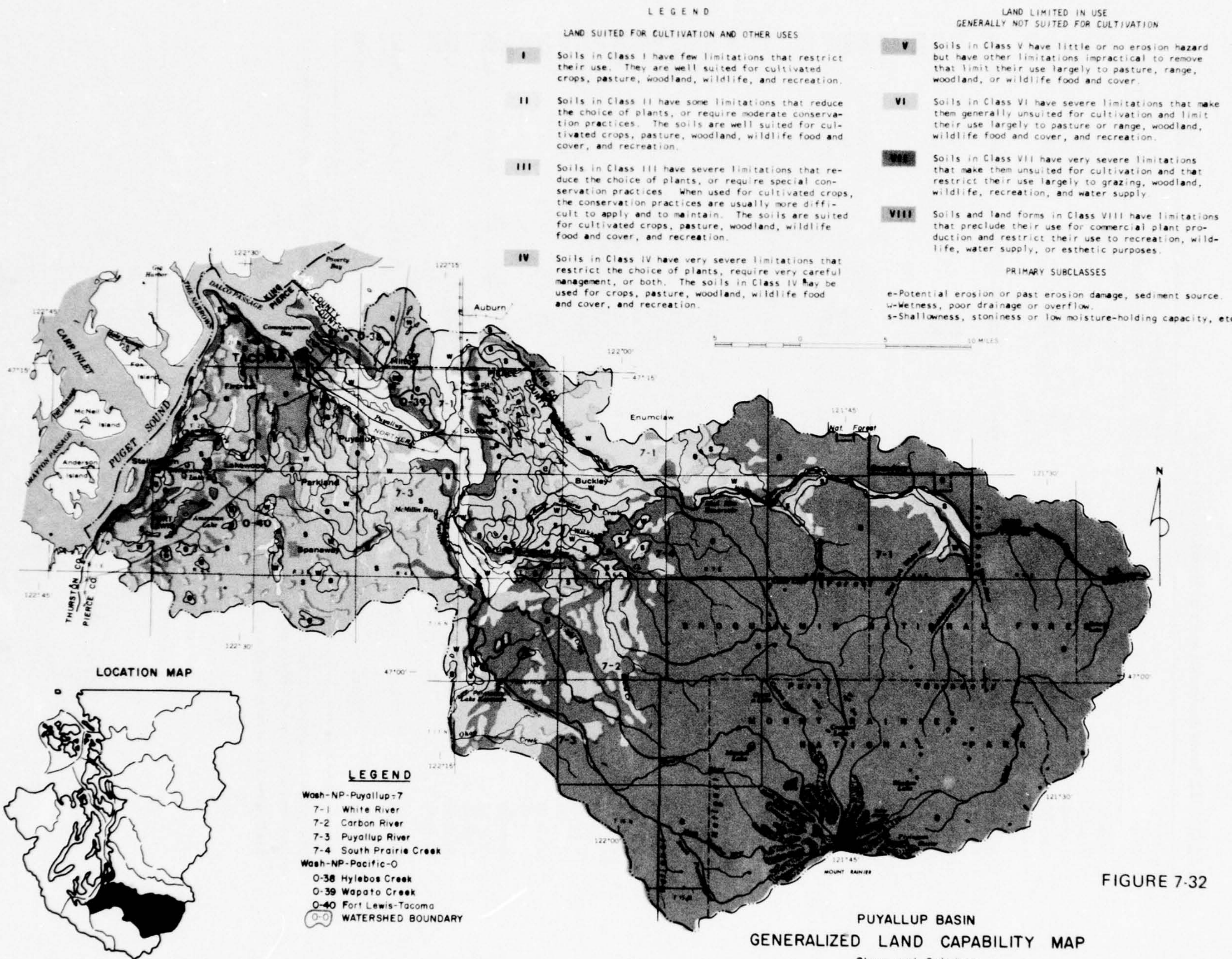


FIGURE 7-32

PUYALLUP BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

TABLE 7-42. Land capability units in Puyallup Basin (acres)[1]

Capability Units[2]	WATERSHEDS 7-1	7-2	7-3	7-4	0-38	0-39	0-40	Total
II ws 02					20	40		60
II ws 03	3,927	274	8,572	12	1,204	2,322	3,553	19,864
II ws 04	838	15	117	95	90	22	27	1,204
II ws 06	1,291	30	394	85	354	10	861	3,025
II ws 09	326	1,083	1,269	92				2,770
II Total	6,382	1,402	10,352	284	1,668	2,394	4,441	26,923
III ew 01	33		780	100	502		762	2,177
III we 17	3,203		7,848	227	334	444	5,359	17,415
III ws 01	430		50	483				963
III ws 03	72							72
III ws 05	65		3	3				71
III ws 08	8		143	10	1		23	185
III ws 09	180	198	309	46	123	22	91	969
III ws 10	10,709	2	530	1,663	34	2	470	13,410
III ws 12	2,453		1,414	670			35	4,572
III Total	17,153	200	11,077	3,202	994	468	6,740	39,834
IV ew 03			45			10	8,180	8,235
IV ew 12	21		49		136		315	521
IV ew 14	90	4,181	9,342	1,998	44			15,655
IV ew 22	12,317	105	6,194	986	8,818	1,040	10,615	40,075
IV es 09	35							35
IV ws 01		25	117	10	35	85	10	282
IV ws 02	442	172	2,390	4	5	50		3,063
IV ws 05		27	18		38	8	19	110
IV ws 06	738	72	1,164	68	608	767	1,120	4,537
IV ws 09	17	10	315	35		11	465	853
IV ws 10	352		8	105	28			493
IV ws 11			58					58
IV so 01	1,039	1,539	400	206				3,184
IV so 10	10		7	5			46,313	46,335
IV so 12					1			1
IS se 05	216	689	2,902	510	223		215	4,755
IV se 13	199							199
IV Total	15,476	6,820	23,009	3,927	9,936	1,971	67,252	128,391
II-IV Total	39,011	8,422	44,438	7,413	12,598	4,833	78,433	195,148

[1] Unadjusted measurements, 1966, for Puget Sound Area Study based on National Cooperative Soil Survey maps. Does not include land within national forest and park boundaries.

[2] See Exhibit 1 for description of capability units.

TABLE 7-42. Land capability units in the Puyallup Basin (in acres)[1] (cont.)

Capability Units[2]	WATERSHEDS 7-1	7-2	7-3	7-4	0-38	0-39	0-40	Total
V ws 21	219							219
V Total	219							219
VI ew 21	2,829	1,800	2,308	2,248	382	209	2,164	11,940
VI ew 26							428	428
VI ew 28	1,062				16			1,078
VI es 19	519	5,977	6,931	3,298	300	54	4,786	21,865
VI es 20	80		5	75				160
VI es 21							20	20
VI ws 19	2,880	393	1,796	150	12		16	5,247
VI so 01	267						3,152	3,419
VI so 12	3,713							3,713
VI so 18	769	65	8,986	650	291		5,914	16,675
VI so 19							323	323
VI so 21							272	272
VI se 13	528							528
VI se 17	3,119	2,198	7,328	2,955	597	115	6,429	22,741
VI se 21							595	595
VI Total	15,766	10,433	27,354	9,376	1,598	378	24,099	89,004
VII es 29			994				1,422	2,416
VII es 36	65,342	22,641	42,510	21,854	1,508	516	4,876	159,247
VII ws 20	396	402	410	60			45	1,313
VII Total	65,738	23,043	43,914	21,914	1,508	516	6,343	162,976
VIII ew 39					5		109	114
VIII ws 00	2,520	574	964	4				4,062
VIII ws 23	12		20		34	332		398
VIII ws 24	108		12	6	17		134	277
VIII so 00	68	33	150	175	240	348	997	2,011
VIII Total	2,708	607	1,146	185	296	680	1,240	6,862
V-VIII Total	84,431	34,083	72,414	31,475	3,402	1,574	31,682	259,061
II-VIII Total	123,442	42,505	116,852	38,888	16,000	6,407	110,115	454,209

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include land within national forest and park boundaries.

[2] See Exhibit 1 for description of capability units.

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the Puyallup Basin will increase from 349,800 in 1967 to approximately 1,157,700 by 2020, based on Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 123,175 acres presently in intensive and rural nonagricultural use could provide ample acreage for new intensive development to the year 1980 without encroachment onto the croplands of the Basin. In order to hold the density per acre to six, an additional 400 acres must be added in the period 1980-2000, and a further increase of 74,900 acres must be added in the 2000-2020 period.

Cropland Needs

The Puyallup Basin presently has 36,853 acres of cropland. A slight decrease in this acreage is expected for each time period so that cropland in 2020 is expected to be 30,000 acres. The percent increases needed, by crops, for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Data in Table 7-43 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

TABLE 7-43. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	33,400[2]	33,400[2]	33,400
Watershed protection and rehabilitation[3]	acre	39,083	37,383	35,683
Drainage improvement	acre	11,952	19,920	26,559
Irrigation development[4]	acre	8,000	10,000	25,000
Water for irrigation[5]	ac.ft.	18,960	23,700	59,250

1 A total of 66,171 acres in the Puyallup Basin are subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated here.

2 Includes 1,700 acres expected to go urban in 2000 and 3,400 acres by 2020.

3 Includes 5,683 acres of rangeland.

4 According to Appendix VII, Irrigation, there were 3,700 acres (using 8,769 acre-feet of water) irrigated in 1966. Irrigation Appendix projections show 6,200 acres irrigated by 1980, 11,200 acres by 2000, and 13,700 acres by 2020.

5 Based on gross diversion requirements of 2.37 acre-feet per acre, estimated by Irrigation Committee in Appendix VII, Irrigation.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Puyallup Basin is summarized under the topic "Program Implementation" immediately following Forestry. A more complete description is found in Appendix XIV, Watershed Management.

FORESTS

PRESENT STATUS

A major portion of the Puyallup Basin is forest covered. 563,000* acres of the Basin, or 72%, is classified as forest land (Table 7-44). Forests are located throughout the Basin with the heavier stands concentrated in the central and eastern parts. Over 113,000 acres of the total forest land is in a reserved classification nearly all of which is in Mount Rainier National Park. Resource zone classifications for the available forest land are shown below:

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	52,530	12
Principal Forest	364,500	81
Upper Forest	30,320	7
Subalpine	1,800	0
Total available	449,150	100

The Puyallup Basin contains over 442,000 acres of commercial forest land capable of producing crops of industrial wood. The sawtimber inventory supported on these lands is 9.2 billion board feet, International ¼-inch Rule (Table 7-45). This area and volume represents 8.8% of the Puget Sound Area's commercial forest land and 9.0% of the sawtimber volume. Private forest lands, located primarily in the central and western part of the Basin, contain some 293,860 acres. This is divided into 240,650 acres in large ownerships (corporate), 680 acres in medium sized ownerships, and 52,530 acres is small ownerships. Public ownerships contain 148,200 acres of commercial forest. This is divided into 83% National Forest, 9% other Federal land, 8% State and County, and negligible amounts of Indian and municipal lands.

The Puyallup Basin supports a well-established forest products industry with a high output of timber products of all types. Of the 27 wood products plants located in the Basin, 17 are located in Tacoma, 2 in Buckley, 3 in Sumner, 2 in Steilacoom, and one each in Orting, Puyallup, and Enumclaw. By industry groupings there are 19 sawmills, 2 of which have wood preservation plants, 4 have reprocessing facilities, 2 have plywood plants and one manufactures hardboard. The remaining 8 plants manufacture plywood and hardboard, however, these also have facilities for reprocessing and preserving wood products. The forest products industry in Puyallup Basin requires about 1,400,000 board feet of material per day. When market conditions warrant additional shifts at the largest plant in Tacoma the raw material need increases by over one-half million board feet.

Problems affecting forest land management in this Basin are described in general terms in the chapter on the Puget Sound Area. Unstable terrain in the steeper glaciated section of the eastern part of Puyallup Basin calls for intensive study and planning in development of access roads and logging systems. The forest products industry has the customary problems inherent with market trends and plant modernization.

*Does not include nonforested lands commonly associated with forest areas.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

No determination of the demand for wood products is made specifically for the Puyallup Basin. The nature of the forest products industries, particularly the relative ease of log transportation between the basins, would make such a determination rather meaningless. In addition, a specific figure would imply that a production goal was established for the basin, which is not the case. Production goals are established for the Puget Sound Area as a whole, with the assumption that considerable shifts in production between the basins will occur, depending upon the actual pattern of industrial and land use development.

TABLE 7-44. Puyallup Basin—Area of forest land, in acres, by ownership and type.

Cover Type of Land Class	National Forest	Other Federal	State & County	Muni-cipal	Indian	Private	Total Avail-able	Unavail-able	Total Avail. & Unavail.
	Available								
Douglas-fir									
seedlings and saplings	290	--	--	20	30	23,140	23,480	1,060	24,540
poletimber	4,490	1,080	2,520	240	130	38,280	46,740	2,840	49,580
small young growth sawtimber	11,560	1,080	--	130	100	24,340	37,210	8,210	45,420
old growth and large young growth sawtimber	22,920	8,660	--	90	10	26,340	58,020	10,690	68,710
True fir—mountain hemlock									
seedlings and saplings	1,420	--	--	10	--	--	1,430	1,770	3,200
poletimber	2,150	--	--	--	--	--	2,150	2,140	4,290
small sawtimber	9,770	--	--	--	--	2,390	12,160	11,410	23,570
large sawtimber	12,000	--	--	170	--	2,410	14,580	13,910	28,490
Western hemlock									
seedlings and saplings	2,360	--	2,450	70	--	32,470	37,350	620	37,970
poletimber	1,860	--	2,180	30	--	16,270	20,340	430	20,770
small sawtimber	13,070	--	2,730	20	--	24,240	40,060	3,240	43,300
large sawtimber	34,830	--	--	30	--	23,230	58,090	7,920	66,010
Western redcedar									
seedlings and saplings	1,140	--	--	--	--	--	1,140	--	1,140
poletimber	--	--	--	--	--	2,320	2,320	--	2,320
small sawtimber	570	--	--	--	20	3,490	4,080	10	4,090
large sawtimber	--	--	--	20	--	3,430	3,450	--	3,450
Lodgepole pine									
small sawtimber	280	--	--	--	10	--	290	--	290
Western white pine									
poletimber	440	--	--	--	--	--	440	--	440
small sawtimber	570	--	--	--	--	--	570	--	570
large sawtimber	290	--	--	--	--	--	290	--	290
SUBTOTAL, softwoods	120,010	10,820	9,880	830	300	222,350	364,190	64,250	428,440
Hardwoods									
seedlings and saplings	--	--	--	--	30	8,060	8,090	10	8,100
poletimber	--	--	1,250	120	320	33,360	35,050	330	35,380
small sawtimber	--	2,170	--	10	250	25,450	27,880	250	28,130
large sawtimber	--	--	--	--	10	1,150	1,160	--	1,160
SUBTOTAL, hardwoods	--	2,170	1,250	130	610	68,020	72,180	590	72,770
Nonstocked									
cutover	2,280	--	--	20	--	3,490	5,790	--	5,790
deforested by fire	--	--	--	--	--	--	--	2,080	2,080
SUBTOTAL, nonstocked	2,280	--	--	20	--	3,490	5,790	2,080	7,870
TOTAL, productive land	122,290	12,990	11,130	980	910	293,860	442,160	66,920	509,080
Subalpine	1,610	--	--	--	--	190	1,800	34,760	36,560
Noncommercial, rocky	4,590	--	--	20	--	580	5,190	12,170	17,360
TOTAL unproductive land	6,200	--	--	20	--	770	6,990	46,930	53,920
TOTAL, all forested land	128,490	12,990	11,130	1,000	910	294,630	449,150	113,850	563,000

TABLE 7-45. Puyallup Basin–Volume of sawtimber and growing stock, by ownership on productive forest land

Species or Group	Available								
	National Forest	Other Federal	State & County	Municipal	Indian	Private	Total Available	Unavailable	Total Avail. & Unavail.
Sawtimber–Thousand board feet, International ¼-inch Rule									
Douglas-fir									
small sawtimber	175,810	16,880	3,700	2,360	1,370	403,110	603,230	128,380	731,610
large sawtimber	1,258,590	404,320	3,710	5,180	600	1,405,920	3,078,320	523,530	3,601,850
True fir–mountain hemlock									
small sawtimber	172,400	--	--	--	--	38,810	211,210	184,380	395,590
large sawtimber	741,830	--	--	9,220	--	142,910	893,960	696,640	1,590,600
Western hemlock									
small sawtimber	197,390	--	38,490	410	--	387,930	624,220	52,180	676,400
large sawtimber	1,828,760	--	3,960	1,710	--	1,212,790	3,047,210	395,360	3,442,570
Western redcedar									
small sawtimber	12,230	--	--	--	460	57,940	70,630	220	70,850
large sawtimber	520	--	--	1,080	--	212,750	214,350	--	214,350
Other softwood species									
small sawtimber	14,100	--	--	--	70	--	14,170	--	14,170
large sawtimber	15,100	--	--	--	--	--	15,100	--	15,100
SUBTOTAL, softwoods	4,416,730	421,200	49,850	19,960	2,500	3,862,160	8,772,400	1,980,690	10,753,090
Hardwoods									
small sawtimber	--	17,430	1,260	190	2,880	282,030	303,790	2,790	306,580
large sawtimber	--	--	1,260	100	800	69,620	71,780	270	72,050
SUBTOTAL, hardwoods	--	17,430	2,520	290	3,680	351,650	375,570	3,060	378,630
TOTAL SAWTIMBER, all species	4,416,730	438,630	52,370	20,250	6,180	4,213,810	9,147,970	1,983,750	11,131,720
Growing Stock – Million Cubic Feet									
Douglas-fir	261.3	76.7	1.3	1.4	0.4	329.5	670.6	118.8	789.4
True fir–mountain hemlock	165.4	--	--	1.7	--	32.9	200.0	159.4	359.4
Western hemlock	394.8	--	8.3	0.4	--	311.9	715.4	87.2	802.6
Other softwood species	16.6	--	--	0.4	0.2	107.2	124.4	0.1	124.5
SUBTOTAL, softwoods	838.1	76.7	9.6	3.9	0.6	781.5	1,710.4	365.5	2,075.9
Hardwoods	--	6.9	1.0	0.1	1.5	139.0	148.5	1.2	149.7
TOTAL growing stock, all species	838.1	83.6	10.6	4.0	2.1	920.5	1,858.9	366.7	2,225.6

For sake of basin comparison, however, there is some value in showing the percentage of demand that may be supplied by the Puyallup Basin in the future. In 2020, the Puyallup Basin is expected to contain about 9% of the commercial forest land in the Puget Sound Area. The percentage in earlier periods is slightly lower. It is, therefore, assumed that the Basin will supply approximately 9% of the total wood products demand in the future.

The effect of competing uses for forest lands is discussed in detail in the section covering the Puget Sound Area. The estimated diversion of forest land from these causes in the Puyallup Basin is shown below:

Type of Land Diversion	Acres Diverted (2020)
Parks, Wilderness, Campgrounds, or other Recreation Use	1,740
Roads and Highways	11,760
Urban-Industrial Development	41,000
Reservoirs, Powerlines, and other miscellaneous conversion	1,500
Private Land Use Reservations	10,000
Total	66,000

The current and prospective changes in the commercial forest land base from all causes are given below.

Specific measures for soil and water protection are discussed in Appendix XIV, Watershed Management.

PROGRAM IMPLEMENTATION AGRICULTURE AND FORESTS

In order to adequately provide for the needs of the Puyallup Basin, as set forth in the previous pages, the following plan has been developed. It is multipurpose in nature and will provide for floodwater damage prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development. Other measures provided for, include water quality and quantity control, recreation, and fish and wildlife development.

This plan contains programs and projects to accomplish specific objectives of conservation and development. They provide for the full development of land presently used for farming, with approximately 7,000 acres of land expected to be lost to other uses by 2020.

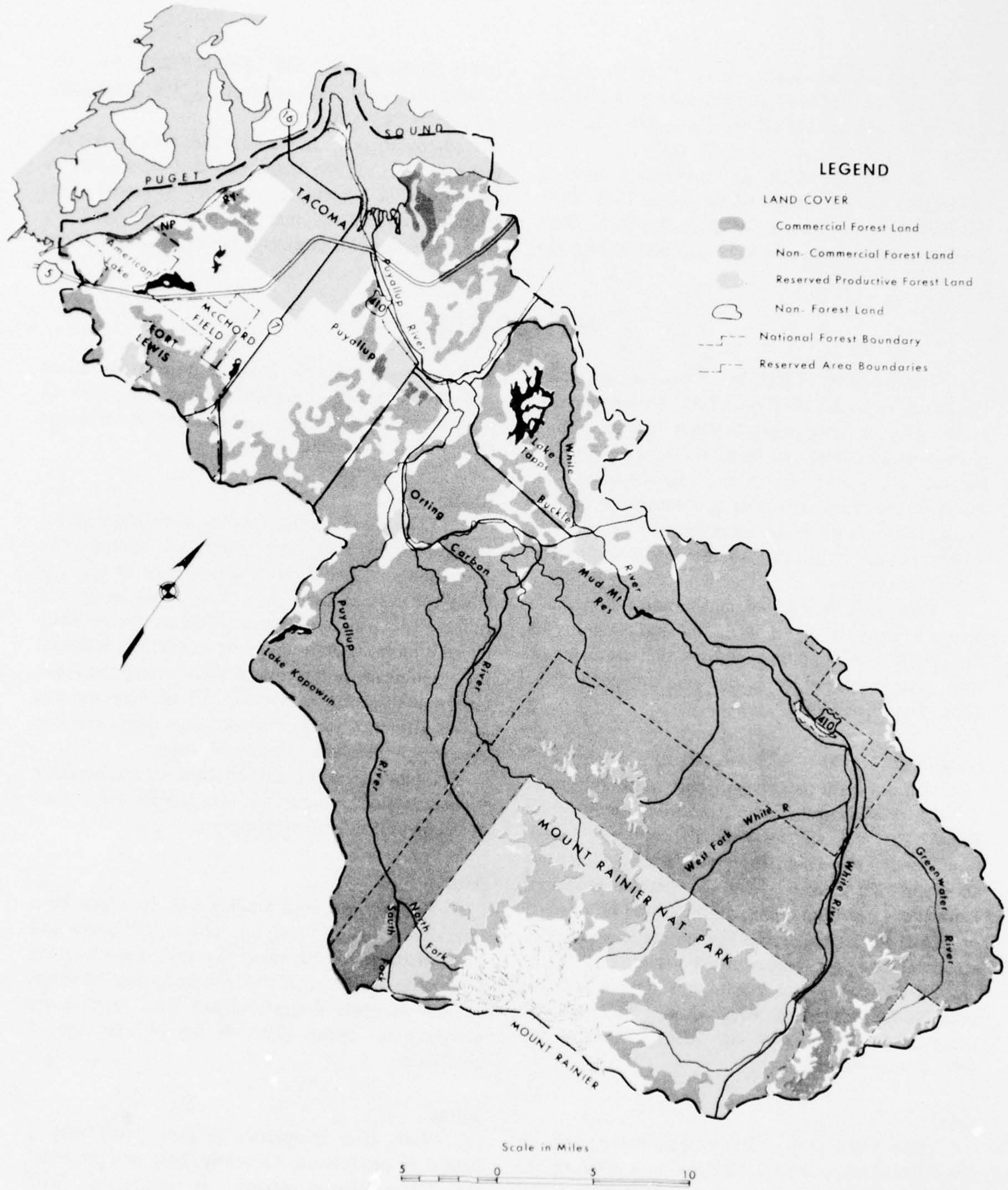
The plan is broken down into three time periods: (a) early action (w.:.nin the next ten years); (b) near future (1980-2000); and (c) distant future (2000-2020).

Program measures refer to on-site practices which take advantage of developments made possible by the structural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management, and irrigation development. Total cost of the program for the early action period is $24,971,000.

There are five early action projects described in Appendix XIV, Watershed Management. Primary agricultural benefits from these projects are prevention of

Current and projected forest area in the Puyallup Basin 1965-2020 (in thousand acres)

	Ownership						
	Private			Public			
Period	Large	Medium	Small	NF	Other Federal	Other	Total
1965	240.7	0.7	52.5	122.3	13.0	13.0	442.2
1980	237.7	0.7	41.3	121.9	13.0	12.7	427.3
2000	234.3	0.7	23.4	120.4	12.8	12.4	404.0
2020	230.8	0.7	1.5	118.8	12.5	11.9	376.2



FORESTS

FIGURE 7-33. Forest lands in the Puyallup Basin

flooding and drainage improvement. The five projects are expected to cost $271,200 annually, and to result in annual benefits of $382,000 for a benefit cost ratio of 1.4 to 1.

Five projects with an installation cost of $4,167,000 are proposed for the period 1980-2000. No projects are planned for after the year 2000. Program costs are expected to be $38,009,000 for the 1980-2000 period and $37,127,000 for the 2000-2020 period. Total cost of the plan is expected to be $109,246,000.

A summary of the early action projects is given in Table 2-21 of the Puget Sound Area section on agriculture. A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, Watershed Management, Puyallup Basin section.

MINERALS

The locations of the known mineral deposits in the Basin are shown on Figure 7-34. The open circles on the maps indicate properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

Coal, sand and gravel, and building stone have played an important part in the mineral economy of the Puyallup Basin. Other minerals that are being or have been produced from the area are peat, clay, silica, copper, and gold.

Sand and Gravel

Some of the largest and best sand and gravel deposits of the Puget Sound Area are in the Puyallup Basin. The deposits near Steilacoom are exceptional—they are high-quality gravel and are located at and near tidewater. Much of the material produced from the Steilacoom deposit is barged to other parts of the Puget Sound Area. Thirteen sand and gravel companies are producing from 14 or more pits.

Sand and gravel production figures are not available for publication. Reserves are estimated to be adequate at the present rate of consumption for several years to come.

Coal

The coal deposits occur in sedimentary rocks of the Puget Group, and are confined to a north-south-trending belt from 3 to 6 miles wide (Figure 7-34). The coal-bearing strata have been folded and faulted, and some seams pitch more than 60°.

Coal was discovered in the area along the Carbon River in 1862. The first recorded production was in 1874. Production rose to a high of 832,272 tons in 1913, but since then, has declined steadily until now only a few hundred tons is produced annually. Production figures indicate that over 21 million tons of coal has been produced. Reserves are estimated at 348 million tons.

Stone

Eight stone quarries have reported production. Breakdown by rock types shows one granite, two sandstone, and five basalt quarries. Most of the rock from the area is used for riprap, landscaping, and rubble. The Wilkeson quarry produces one of Washington's most attractive building stones. The Wilkeson rock is a cream to tan-colored sandstone of the Puget Group that resists weathering for outdoor use and also is attractive for indoor uses. It is used as rubble, cut stone, ashlar, and ornamental stone.

Figures on production of stone are not available for publication. Reserves are adequate for many years at the present rate of consumption.

Peat

Sixteen peat bogs totaling 843 acres have been investigated. The largest one covers 250 acres, and three of them contain sphagnum peat. Four bogs are productive in the area; production figures, however, are not available for publication. Peat reserves are adequate for many years at the present rate of production.

Silica

Two silica properties (Figure 7-34) have a record of production. Currently, only one property, the Denny-Renton quarry, is producing. Both deposits are large masses of silicified and bleached andesite. The Denny-Renton quarry material is used for building stone, stucco dash, and terrazzo chips. Silica from the other quarry was used as an ingredient in the manufacture of portland cement.

No information is available as to how much

material has been used from the two quarries. Total reserves are not known, except they are reported to be large.

Clay

One clay pit is reported to have had production. This pit at Ruston, which contains common clay, has been covered by housing developments and is no longer in use. One other clay deposit in the area contains bentonitic clay interbedded with perlite.

No production or reserve figures are available for the clay deposits.

Alunite

The Enumclaw alunite ore body consists of disseminations and fracture fillings of alunite in altered andesite. Extensive drilling in 1940 indicated 588,000 tons of alunite in the deposit, but as yet no attempt has been made to mine it.

Perlite

Four perlite deposits are known, but none of them have been worked.

Diatomite

The Parkland diatomite deposit is reported to be 15 to 30 feet thick and covers 30 acres. No material has been produced from this deposit.

Copper

Of seven copper properties, one has had production, and test shipments have been made from two. The Starbo mine (Figure 7-34, No. 104) had production during 1915-17, 1926, and 1928 from lenticular irregularly mineralized fractures up to 1 foot wide in andesite. Production figures are not available.

INTENSIVE LAND USE

Pierce County had an estimated 1967 population of 378,298. This represented over twice as many persons as the 182,081 population of Pierce County in 1940. Projections for 1970 show a county population of 390,000. There are some 16 incorporated cities and towns in the Puyallup Basin and approximately ten unincorporated towns, with the bulk of the population in the northwest corner of the Basin.

INCORPORATED CITIES AND TOWNS

Tacoma

The city of Tacoma is the major urban settlement in the Puyallup Basin with a 1967 population of 156,000. It is the county seat, the largest city in Pierce County, and the third largest city in the State. Located on Puget Sound south of Seattle on Commencement Bay at the mouth of the Puyallup River, Tacoma has long been a major lumber city with a waterfront crowded with lumber and manufacturing plants. Explorations to Tacoma occurred as early as 1792, but the first land claim was not until 1864, four years preceding the town's selection as the future terminal of the Northern Pacific Railroad. In 1873 the railroad reached Tacoma from Portland and a year later, the city was incorporated, with a population of about 200. By 1890, however, growth was well underway, and the city had some 36,000 people.

Lumber and related industries, metallurgical industries, aluminum, ferro-alloys, casting, and the largest combined copper smelter and refinery in the United States, chemical and electro-chemical products, food processing, machinery, clothing, and boat and shipbuilding, have caused continuous growth for the city, with the largest population increases occurring between the periods of 1900 and 1910, and 1940 and 1950. The smallest changes occurred between 1930 and 1940, and 1950 and 1960.

Tacoma has one of the five best natural harbors in the world, is an important port and railroad terminus, and is the closest metropolitan gateway to all five entrances to Mount Rainier National Park.

Puyallup

The city of Puyallup, approximately nine miles southeast of Tacoma and 38 miles south of Seattle, on the Puyallup River, was incorporated in 1890 with less than 200 people. By 1940 the city had a population of 7,889, and by 1960, 12,063. The 1967 population showed a steady increase to 14,200 and the 1970 projections indicate a considerable increase to 18,000. Puyallup's buildup as an industrial area has been the principal factor responsible for population

MINERAL PROPERTIES IN PUYALLUP BASIN*

Explanation for Figure 7-34

Metallic Minerals

(with production or reserves data where available)

Copper (7 properties)
- 98 – Copper King
- 104 – Starbo
- 99 – Surprise

Gold (12 properties)
- 102 – Silver Creek (prod.–100 tons)
- 100 – Silver Creek Gold & Lead (prod.–20 tons)
- 101 – Silver Creek Placer
- 103 – Washington Cascade (prod.–5 tons)

Zinc (1 property)

Stone Deposits

Basalt (5 properties)

Granite (1 property)

Sandstone (2 properties)

Nonmetallic Minerals

(with reserves data where available)

Alunite (reserves–588,000 tons)
- 86A – White River

Coal (reserves–347.8 million tons)

Common clay (1 property)
- 84 – Ruston

Diatomite (2 properties)

Perlite (4 properties)

Silica (2 properties)
- 86 – Denny-Renton
- 85 – Superior

Special clay (1 property)

*Some properties not plotted on map because of poor description of location and/or lack of space.

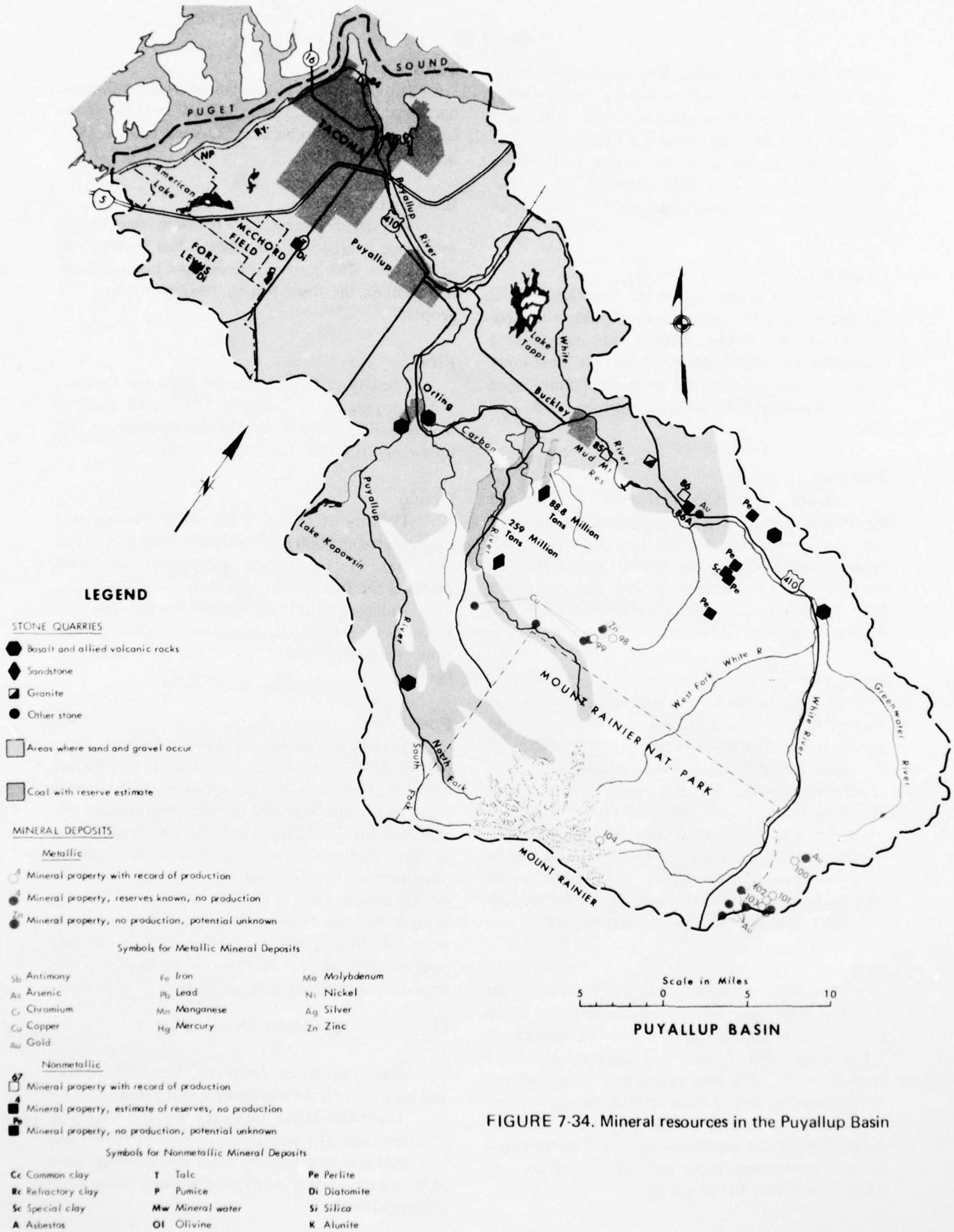


FIGURE 7-34. Mineral resources in the Puyallup Basin

growth. The fertile Puyallup Valley is famous for its agricultural products, such as berries, flower bulbs, and truck crops; and the chief industries of the city are food processing and wood products plants. The area is especially noted as the leading producer of daffodil bulbs. A State Fish Hatchery where four million trout are raised annually is located at Puyallup.

Fircrest

The third largest city in the Puyallup Basin is Fircrest with a 1967 population of 5,006. A residential suburb of Tacoma, Fircrest was incorporated September 19, 1925, and has shown the most rapid growth of any municipality in Pierce County since 1940, increasing 930 percent between 1940 and 1967.

Buckley

The city of Buckley, first settled in 1853, and the trading center of a rich agricultural, lumbering and mining area, was incorporated May 26, 1890. Located on the White River east of Tacoma, Buckley has grown from a small trading center to a city with a 1967 population of 3,650, an increase of approximately 1,000 people since 1950.

Steilacoom

The city of Steilacoom is located southwest of Tacoma on Puget Sound facing Anderson Island and McNeil Island. The townsite was platted in 1853 and the town incorporated in 1854, making it the first incorporated town in Washington and the county seat of Pierce County until 1880. In former days, the town was a sawmill and lumber shipping and shipbuilding center, but today it is predominantly a small suburban residential city which has retained many historic buildings and landmarks. The 1950 population was 1,233, and the 1967 population, 2,059.

Sumner

The city of Sumner, east of Tacoma in the Puyallup Valley, was incorporated in 1891 and today (1967) has a population of 3,950, an increase of 1,134 since 1950. Sumner is a small industrial and trading center of a rich agricultural area, and the headquarters of several State agricultural associations. In addition to packing plants, canneries, and floral supply houses, the manufacturing of Fleishman yeast, vinegar, insecticides, paper and paper products, and lumber contribute to the economy.

Milton

The city of Milton has evolved from a mill town northeast of Tacoma, incorporated in 1907, to a largely residential suburb of Tacoma with a 1967 population of 2,600.

Bonney Lake

The city of Bonney Lake has been incorporated only since February, 1949, when it had a population of less than 250. East of Tacoma and just northeast of Puyallup, the town had by 1967 grown to 2,061 people.

Fife

The city of Fife, residential suburb of Tacoma, was incorporated in February 1957, with approximately 1,300 residents. By 1967, the population was up slightly to 1,524.

Orting

The city of Orting, southeast of Tacoma, was incorporated in 1890 and reported a 1967 population of 1,600. Chief industries are lumber and wood products and food processing plants.

Unincorporated townships in the Puyallup Basin include Parkland, Spanaway, Kaposwin, Electron, Ashford, Paradise Inn, Sunrise, and Crystal Mountain.

Fort Lewis

Fort Lewis, the second largest permanent Army post in the United States and headquarters of the 4th Infantry Division, is located approximately 10 miles south of Tacoma. Included in the general area are also McChord Air Force Base; Camp Murray, headquarters of the Washington National Guard; and various auxiliary facilities. In 1966 there were approximately 64,300 members of the military and their dependents living within the boundaries of the military reservation. Of course, the population of the military reservation tends to fluctuate from time to time, depending on military circumstances.

TRANSPORTATION

Rail—The Great Northern, Northern Pacific, and Milwaukee Railroads operate in the Basin.

Highways—Major highways are U.S. Highway 99 (Interstate 5) running from south to north, and U.S. Highway 410 running from east to west. State highways and county roads provide ready access to all populated areas.

Airways—The Seattle-Tacoma International Airport provides air transportation for people in the Tacoma area, as does Tacoma Industrial Airport. Numerous small airfields provide airport facilities for local needs.

Navigation—Excellent harbor facilities exist at the mouth of the Puyallup River. Above the tide flow, however, navigation is almost nonexistent.

LAND USE CHARACTERISTICS

There are approximately 759,234 acres of land within the Puyallup Basin and some 11,297 acres of inland water. Table 7-40 contains the figures showing the acreage of the major land uses within the Basin.

Figure 7-31 portrays the present intensive land use areas for the Puyallup Basin. It can easily be seen that the intensive land use is grouped in the area of the city of Tacoma, and its surrounding environs.

Intensive Land Use

At the present time (1967) intensive land uses occupy some 97,446 acres or 12.8 percent of the Basin's land area. Nearly all of the intensive land use areas are located within or near the Basin's incorporated and unincorporated communities, although a few intensive uses will be found at scattered locations throughout the Basin. The following list contains the land use figures for the intensive land use subgroups.

Railroads	Roadways	Airports	Urban (Built-up)	Total
2,636	4,920	3,270	86,620	97,446

Rural Nonagricultural

Since many of the land uses classified within the rural nonagricultural category are similar in character and often associated with or the forerunners of intensive land use, they have been included within the text for the convenience of the readers. The following list shows the several subgroups in the rural agricultural category.

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm yards)	Total
21,042	900	137	3,650	25,729

Land Ownership

Of the total land area (759,234 acres) in the Puyallup Basin, 24.5 percent is in private ownership, 31.1 percent in private corporate ownership, 39.9 percent in Federal ownership, 3.0 percent in State ownership and 1.4 percent in local government ownership. The bulk of the private corporate and Federal ownerships are forested or park (Mount Rainier areas located in the eastern half of the Basin). Land areas owned by local governments (city, county and special districts) are largely located in the western third of the Basin. These land areas are mainly related to intensive use, consisting of streets, facilities, local parks and similar areas. Other (nonforest) private ownerships are also located primarily in the western third of the Basin and consist mainly of intensive and rural nonagricultural and agricultural land areas.

TRENDS AND POTENTIALS

Intensive land use in the Puyallup Basin amounts to some 97,446 acres or slightly more than four (4) townships of land. This area accounts for approximately 13 percent of the total Basin area. The major intensive land use requirements are presently being filled in and around the cities of Tacoma and Puyallup. The Fort Lewis Military Reservation in the southwest portion of the Basin also contains a significant amount of intensive land use. There is a great deal of suburban development located between Fort Lewis and the city of Tacoma. Within the Puyallup Basin there are approximately thirteen (13) townships comprising some 309,000 acres considered most likely to receive pressure for intensive development. This potential growth area is located mainly southeast of Tacoma including the Puyallup River Valley floor. The present trend that exists in the Puyallup River Valley is that the farmers wish to preserve their option for a speculative sale for any type of use of their land. But from the aspect of good land planning, there should be an effort made to maintain for future use, a portion of the Puyallup River Valley floor in its present use of agriculture production. There exists in near proximity to the river valley, ample less productive lands that are available, and suitable for most intensive uses, especially those uses which can be classified as residential, and which represent the prime user of land in the intensive land use category.

The potential for increased port industrial development is limited in the Puyallup River Basin (Tacoma area) because of freeway development southeast of the port facility. Industrial development not requiring port facilities should be guided to other areas within the Basin. Preliminary investigations are now underway to determine land areas that are suitable to provide additional port facilities for this Basin. One of the areas of primary concern at this time is the Nisqually flats just outside of the Basin.

PRESENT AND FUTURE NEEDS

Present trends for intensive land use in the Puyallup River Basin show expansion of facilities at almost a boom rate, as is being experienced throughout the central portion of the Puget Sound Area.

Population of the Puyallup River Basin was 349,800 in 1967. Without the cross-Sound bridge this will increase to 449,800 by 1980; 721,000 by 2000; and to 1,157,700 million people by the end of the planning period in 2020. By the end of the planning period, there will be a need for approximately 144,200 acres of land to be put to intensive land uses. The density for the Basin is projected to be eight persons per acre. Figure 7-35 portrays the future land use pattern (C_2) for the Puyallup Basin in the year 2020 assuming construction of the cross-Sound bridge. This pattern will result in a need for 138,200 acres of intensive use land by the year 2020.

Present industry in the Basin includes lumber and food processing, metallurgical industries, aluminum, ferro-alloys, casting, copper smelting and refining, chemical and electro-chemical products, plus many other industries. These industries, with the exception of lumber and food processing, are expected to grow and expand to meet the needs of the Puget Sound Area in the future. With Mount Rainier National Park located within the Basin, the tourist industry will continue to grow and will demand lands for the various tourist-oriented facilities.

Present trends show that the Puyallup River Valley is destined to develop intensively from the mouth of the river to the city of Puyallup, plus that there is a good possibility that the fertile agriculture lands between the cities of Puyallup and Orting may be developed intensively. Local efforts have not been successful in gaining support to keep the land in its present agriculture use. The present zoning of the lands in the Puyallup Valley is general use which permits almost all uses. Efforts are being made to zone portions of the valley industrial reserve, which would limit acreage size for development, and permit only industrial uses to develop the land. Under this type of zoning the valley could be kept in productive agriculture use until such time as there is a demand for industrial land.

Projections have been made to determine those areas within the Puyallup River Basin that are likely to receive pressures for intensive development by the year 2020. There were 300,000 acres of land projected to receive pressures for development by the year 2020. From the population projection, and a density factor of eight persons per acre, there is a need for an additional 40,800 acres of land for intensive uses by the end of the projected planning period. From the 300,000 acres likely to receive pressure for development, only one-half of this amount will be needed, thus development should be on a highly selective basis with intensive land use being developed on those lands which are best suited for these uses. With this in mind, an effort should be further extended to try and keep some of the fertile Puyallup Valley in agriculture production.

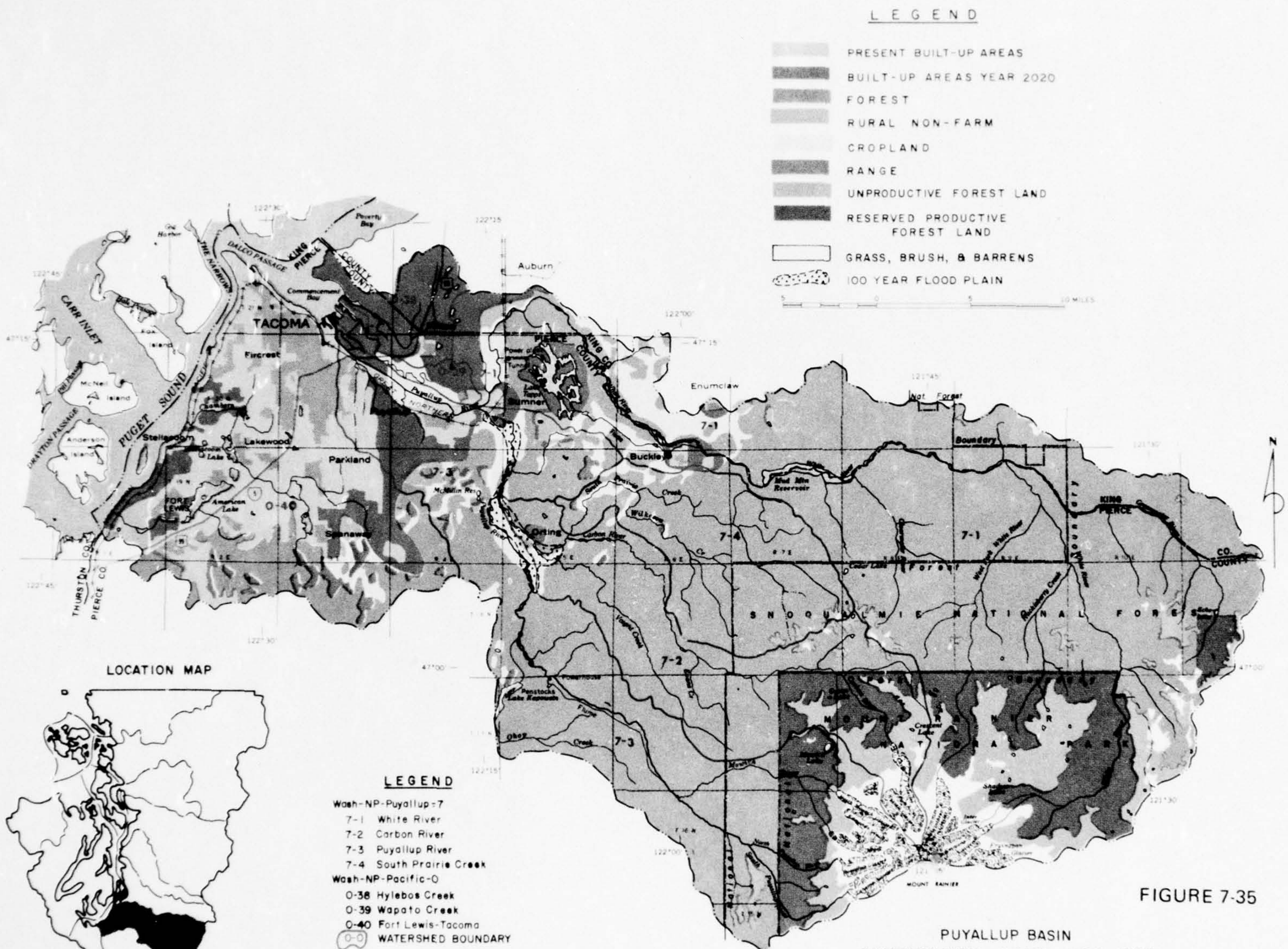
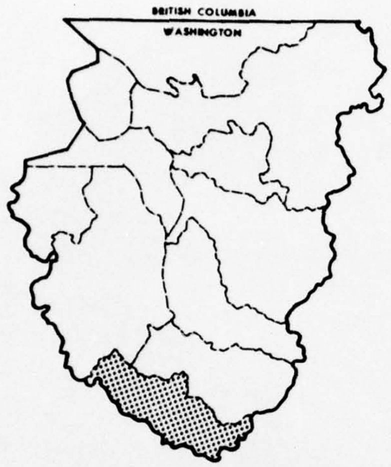


FIGURE 7-35

PUYALLUP BASIN
GENERALIZED LAND USE MAP
Alternative C2 –2020

NISQUALLY-DESCHUTES BASINS



The Nisqually-Deschutes Basins are located in Pierce and Thurston Counties and extend into Lewis County south and west of Mount Rainier. The hydrologic area for these two river basins in the central sector of the Puget Sound Area is 645,659 acres. Important tributaries entering the Nisqually River are Muck Creek, Ohop Creek, and Mineral Creek. There are no side streams of importance entering the Deschutes River.

Population

The population of the Basins in 1967 was 70,100 persons. This population is primarily located in the western portion of the Basin in the Olympia area. Projections show increases in population by 1980 to 74,900, to 104,500 by 2000 and to 146,500 persons by 2020. This new growth will take place primarily adjacent to the existing developed areas.

Land Use

The primary land use in the Nisqually-Deschutes Basins is forests and associated lands with over 78% of the total Basin being put to this use. The other two primary land uses, croplands and urban or built-up account for 7% and 3%, respectively. Also, rangeland accounts for approximately 7% of the total. Table 7-46 shows the tabulation of present land use within the Basins. Figures 7-36A and B, the generalized land use maps of the Nisqually-Deschutes Basins, portrays the land areas occupied by each of the major uses.

TABLE 7-46. Land use in Nisqually-Deschutes Basins (in acres)[2]

Map No.	Watershed	Crop-land	Range-land	Total Forest[2]	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
0-41	Muck Creeks	9,979	15,685	41,697	1,384	1,787	344	70,876
0-42	Horn-Tanwax Creeks	4,433	4,052	24,457	572	292	819	34,625
0-43	Ohop Creek	2,009	85	24,720	469	321	439	28,043
0-44	Mashel River	560	545	52,327	220	548	34	54,234
0-45	Nisqually River	12,273	13,641	236,474	3,723	2,533	5,832	274,476
	Total Nisqually Basin	29,254	34,008	379,675	6,368	5,481	7,468	462,254
0-46	Deschutes River	6,650	6,466	76,276	2,348	4,308	817	96,865
0-47	Henderson Inlet Area	8,524	2,109	36,281	8,426	7,164	1,497	64,001
0-48	West Budd Inlet Area	1,074	905	14,566	2,767	2,944	283	22,539
	Total Deschutes Basin	16,248	9,480	127,123	13,541	14,416	2,597	183,405
	Total Nisqually-Deschutes Basins	45,502	43,488	506,798	19,909	19,897	10,065	645,659

1 Includes alpine and other nonforested areas normally associated with forest.

2 Unadjusted measurements, 1966 Puget Sound Area Study.

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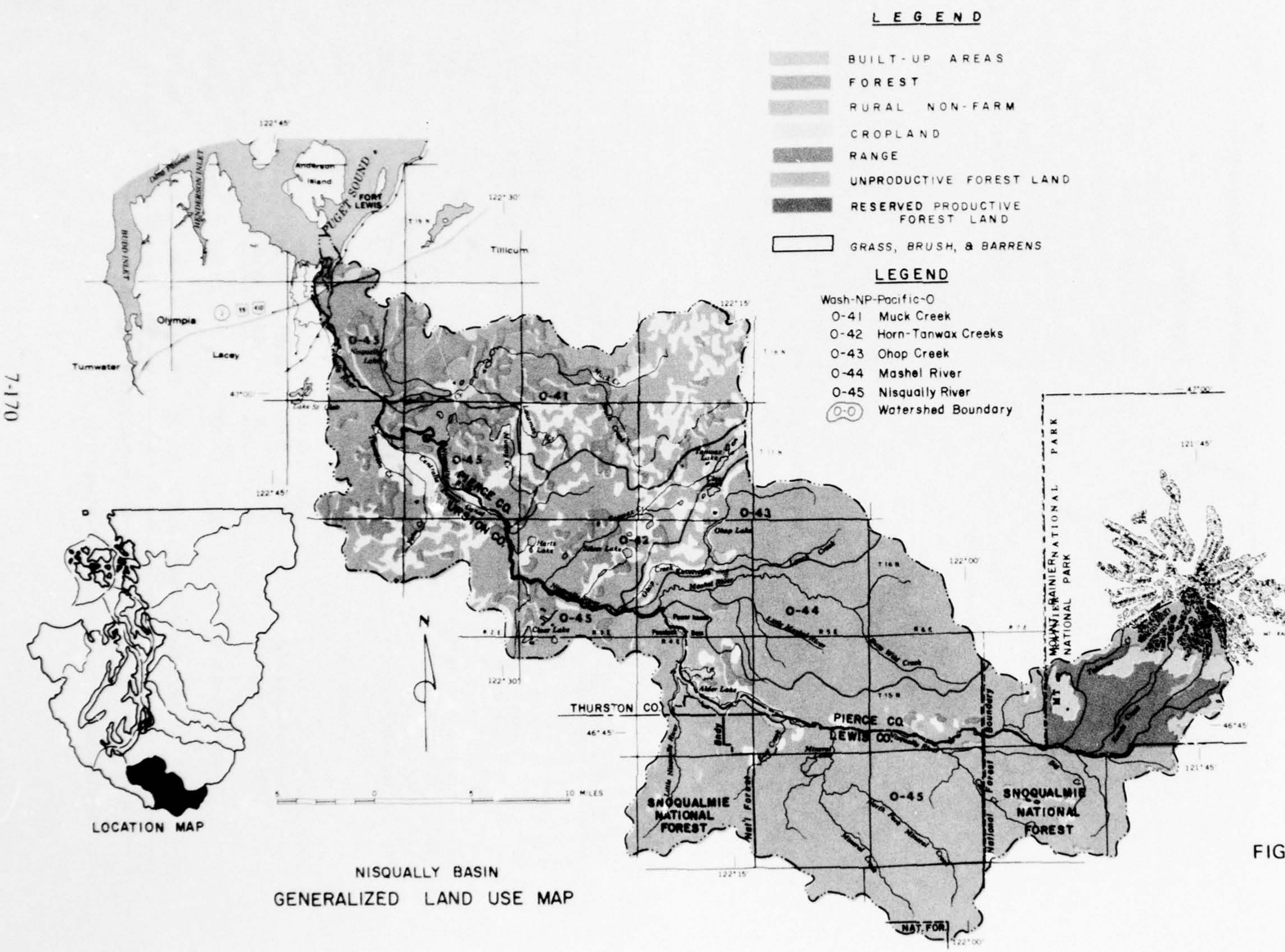
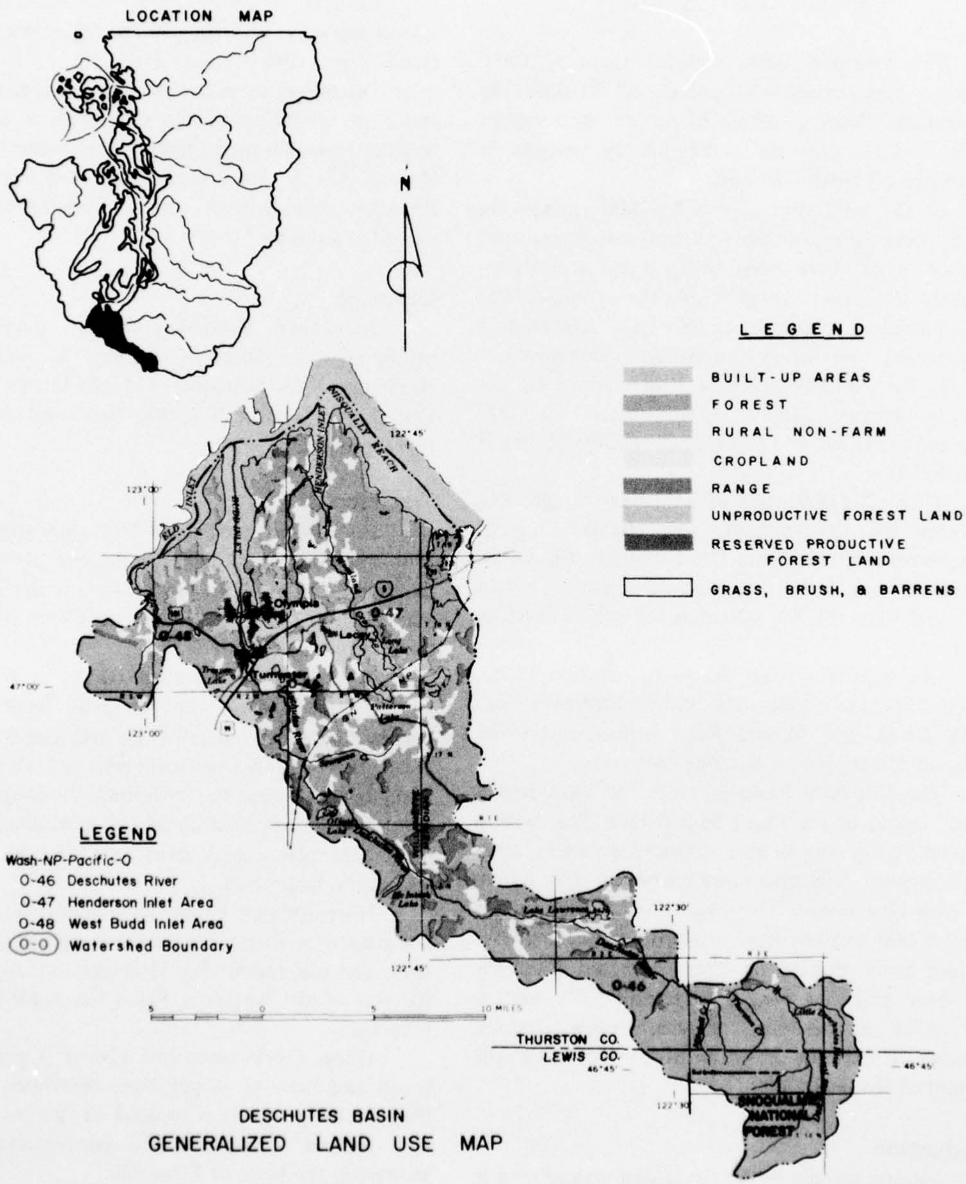


NISQUALLY BASIN
GENERALIZED LAND USE MAP

FIGURE 7-36A



DESCHUTES BASIN
GENERALIZED LAND USE MAP

FIGURE 7-36B

AGRICULTURE

PRESENT STATUS AND POTENTIAL

NISQUALLY BASIN

The Nisqually Basin includes parts of three counties. Approximately 60 percent of the Basin lies in southern Pierce County, 30 percent in northern Lewis County, and the remaining 10 percent in northeastern Thurston County.

Of the total land area of 454,800 acres in the Basin, those lands outside the national forests and national parks have been mapped by a medium-intensity soil survey. Lands within the national forest and national park boundaries have been mapped by a low-intensity soil survey suitable for reconnaissance use. Of the 363,545 acres of land mapped by the medium-intensity survey, approximately 208,000 acres are classified in Land Use Capability Classes II through VI.

These 208,000 acres of land have the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, and IV are suited for either cropland or urban uses, and Class VI has potential for urban development.

The Nisqually River drains an area of approximately 720 square miles. The principal tributaries are Muck Creek and Mashel River which enters the Nisqually River below LaGrande Canyon.

The Nisqually Basin provides the sixth largest valley system in the Puget Sound Area. This system includes many flood and drainage problem areas which require corrective measures before their potential may be attained. The lower flood plain contains about 6,000 acres of level or gently undulating river bottom lands, and the remaining cropland lies above the flood plain on benchland terraces. The eastern portion of the Basin has extremely rugged terrain, reaching an extreme elevation of 14,408 feet at the summit of Mount Rainier.

Production

Forests occupy by far the largest area of land in the Basin, with cropland running third. Farming is of a mixed variety. Livestock raising, dairying, berry growing, poultry raising, and specialty crops such as bulbs, flower plants, commercial shrubs, and herbs, play an important part in the economic welfare of the area. The total value of farm production is over $10 million annually.

Flooding

Climatic conditions induce one flood-producing season annually, occurring in the fall or winter as the result of excessive precipitation.

Discharges in excess of channel capacity cause water to spread across the valley, where it remains until the river drops. In many areas, water is trapped by topographic detail until it can seep into the soil. Excessive rainfall causes similar flooding conditions, as well as swamping of the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV. Principles and conditions discussed therein apply to the Nisqually Basin and need not be repeated here.

Watersheds

Five watershed areas requiring solutions to problems or development to achieve potential productivity of the Basin are shown on the Land Use Map (Figure 7-36A) and on the Generalized Land Capability Map (Figure 7-37A).

Muck Creek watershed (0-41) is the second largest watershed in the Nisqually Basin. Forests occupy the greater part of the watershed but large areas of cropland and rangeland are also present. Although urbanization is limited, housing developments are being constructed and additional developments are planned. A large area of Fort Lewis is within this watershed.

Horn-Tanwax Creek watershed (0-42) is predominantly in forest, with some cropland and rangeland, and not much else. Urbanization, as is true of the rest of the Nisqually Basin, has made very little progress.

Ohop Creek watershed (0-43) is primarily in forest and has not, as yet, been developed for other than forest products. Cropland in this watershed is very limited. Urbanization is concentrated almost entirely in the town of Eatonville.

The watershed of Mashel River (0-44) is heavily forested, with better than 95 percent of the total area of the watershed used for this purpose. Potential use would seem to be oriented to forestry.

Nisqually River watershed (0-45) is by far the

largest watershed in the Basin. It contains 86 percent of all forest lands, 42 percent of the cropland, and 40 percent of the rangeland in the Basin.

The Nisqually River flood control system is not adequate, limiting use of the flood plain to recreational and agricultural developments that can be carried out in consonance with the frequent flooding. Urbanization of the watershed is proceeding rapidly in certain areas. Farming and forestry probably will continue as the most important industries in future years.

Many of the farm lands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions are summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the Nisqually Basin is shown in Table 7-46. The following tables are to indicate the potential development possible within acceptable land use standards.

Table 7-47 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-48 shows the number of acres in each capability class, subclass, and unit, by watersheds, in the Nisqually Basin. This table can be used with the description of capability units to estimate the potential for development.

TABLE 7-47. Distribution and value of production by crops in Nisqually Basin

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	223	274	.94	13,221	.31
Field crops	58	71	.24	21,212	.50
Vegetables	954	1,170	4.00	251,063	5.88
Berries	746	915	3.13	941,886	22.07
Nursery products	645	791	2.70	1,379,725	32.32
Cropland not used	1,991	2,442	8.35	--	--
Sub-Total	4,617	5,663	19.36	2,607,107	61.08
Hay	6,173	7,571	25.88	354,865	8.31
Hay aftermath	--	--	--	202,190	4.74
Sub-Total	6,173	7,571	25.88	557,055	13.05
Silage (grass)	1,165	1,429	4.88	94,675	2.22
Grass aftermath	--	--	--	38,375	.90
Sub-Total	1,165	1,429	4.88	133,050	3.12
Silage (corn) fodder	134	164	.56	10,865	.25
Pasture (cropland)	11,762	14,427	49.32	960,419	22.50
Sub-Total	19,234	23,591	80.64	1,661,389	38.92
Total	23,851	29,254	100.00	4,268,496	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.

LEGEND

LAND SUITED FOR CULTIVATION AND OTHER USES

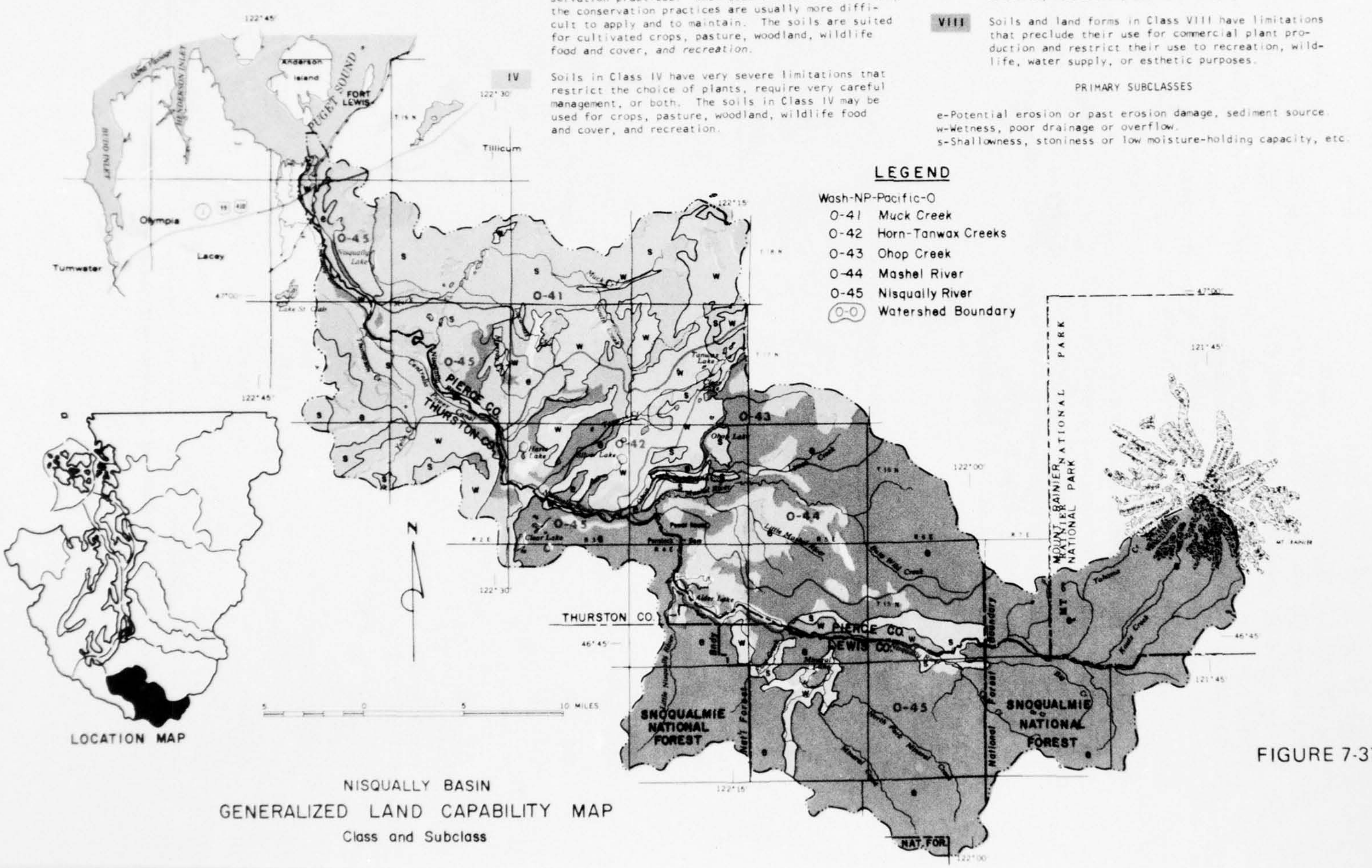
Class	Description
I	Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.
II	Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
III	Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
IV	Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

Class	Description
V	Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.
VI	Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.
VII	Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.
VIII	Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.



NISQUALLY BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

FIGURE 7-37A

AD-A037 573 PACIFIC NORTHWEST RIVER BASINS COMMISSION VANCOUVER WASH F/G 8/6
COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
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TABLE 7-48. Land capability units in Nisqually Basin (in acres)[1]

Capability Units[2]	WATERSHEDS 0-41	0-42	0-43	0-44	0-45	Total
II ws 03	633	35	5		738	1,411
II ws 04		25	270		420	715
II ws 06	1,007	882	27	180	1,169	3,265
II ws 09	258	166				424
II so 01					596	596
Class II Total	1,898	1,108	302	180	2,923	6,411
III ew 01	149	8			676	833
III es 02	16,590	14,698	3,232	585	40	40
III we 17			232		38	35,143
III ws 01					1,932	2,164
III ws 02					20	20
III ws 03			352		20	20
III ws 05	39				180	532
III ws 08	792	287	15		109	148
III ws 09	989	658	52	21	1,138	2,232
III ws 10	1	25			2,288	4,008
III ws 12					5,129	5,155
III so 08					1,059	1,059
Class III Total	18,560	15,676	3,883	606	12,629	51,354
IV ew 03	3,067	840	20	78	3,715	7,720
IV ew 12	11	18			105	134
IV ew 14	18	5	4,104	7,719	5,000	16,846
IV ew 22	258				5,339	5,597
IV es 07					1,133	1,133
IV es 09					710	710
IV es 16					5	5
IV ws 01		130			140	270
IV ws 02					80	80
IV ws 05		10			8	18
IV ws 06	1,153	628	281	20	810	2,892
IV ws 07					348	348
IV ws 09	1,543	883	25		1,798	4,249
IV ws 10					95	95
IV ws 11			37	207	542	786
IV so 01				5		5
IV so 10	23,915	80	65		12,895	36,955
IV so 12	40	2			3,128	3,170
IV se 05	654	347	5		909	1,916
IV se 11					14	14
IV se 09					847	847
Class IV Total	30,659	2,944	4,537	8,029	37,621	83,790
Class II-IV Total	51,117	19,728	8,722	8,815	53,173	141,555

1 Does not include lands within national forest or park boundaries.

2 See Exhibit 1 for description of capability units.

TABLE 7-48. Land capability units in Nisqually Basin (in acres)[1] (cont.)

Capability Units[2]	WATERSHEDS 0-41	0-42	0-43	0-44	0-45	Total
VI ew 21	169	1,728	1,364	3,065	2,560	8,886
VI ew 26	85	200			110	395
VI ew 28					2	2
VI es 18					50	50
VI es 19	1,539	542	834	180	2,824	5,919
VI es 20					65	65
VI es 21					2,556	2,556
VI es 25	34	743		90	38	38
VI ws 19	1,915				2,176	3,043
VI so 01					1,193	3,108
VI so 12	3,486	1,871	482	404	3,755	3,755
VI so 18	20				5,523	11,766
VI so 19	128				277	297
VI so 21	10,457	2,580	1,043	940	2,148	2,276
VI se 17	75				9,265	24,284
VI se 21					65	140
Class VI Total	17,908	7,665	3,723	4,679	32,606	66,580
VII es 29	982	3,785	476	165	8,421	13,829
VII es 36	525	2,546	14,669	40,522	80,062	138,324
VII ws 20			10	2	360	372
VII so 23					1,649	1,649
Class VII Total	1,507	6,331	15,155	40,689	90,492	154,174
VIII ws 00		60	4	15	920	999
VIII ws 23					197	197
VIII ws24		23		2	15	40
Class VIII Total		83	4	17	1,132	1236
Class V-VIII Total	19,415	14,078	18,882	45,385	124,230	221,990
Class II-VIII Total	70,532	33,806	27,604	54,200	177,403	353.545

[1] Does not include lands within national forest or park boundaries.

[2] See Exhibit 1 for description of capability units.

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the Nisqually Basin will increase from 19,500 persons in 1963 to approximately 46,100 by 2020, according to Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 11,849 acres presently in intensive and rural nonagricultural use could provide ample acreage for new intensive development to the year 2020 without encroachment onto the croplands of the Basin.

Cropland Needs

This Basin presently has 29,254 acres of cropland. Pressure from other uses is expected to be of such magnitude that cropland will decrease in each time period, with approximately 9,650 acres remaining by 2020. Percent increases needed, by crops, for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Data in Table 7-49 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

TABLE 7-49. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	15,986[2]	15,986[2]	15,986
Watershed protection and rehabilitation[3]	acre	53,957	48,555	43,652
Drainage improvement	acre	3,593	5,988	7,984
Irrigation development[4]	acre	3,500	4,500	7,715
Water for irrigation[5]	ac.ft.	8,295	10,665	18,285

[1] A total of 36,544 acres in the Nisqually Basin is subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated here.

[2] Includes the following acreages expected to go into other uses: 1,439 acres by 2000, and 6,342 acres by 2020.

[3] Includes 34,008 acres of rangeland.

[4] According to Appendix VII, Irrigation, there were 2,900 acres (using 6,873 acre-feet of water) irrigated in 1966. Irrigation Appendix projections show 4,000 acres will be irrigated by 1980; 6,600 acres by 2000; and 10,800 acres by 2020.

[5] Based on gross diversion requirements of 2.37 acre-feet per acre, estimated by the Irrigation Committee in Appendix VII, Irrigation.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Nisqually Basin is summarized under the topic "Program Implementation" immediately following "Forestry." A more complete description is found in Appendix XIV, Watershed Management.

PRESENT STATUS AND POTENTIAL

DESCHUTES BASIN

The Deschutes Basin includes parts of two counties. Approximately 90 percent of the Basin lies in eastern Thurston County, with the remaining 10 percent in northeastern Lewis County.

Of the total land area of 180,808 acres in the Basin, those lands outside the national forest boundaries have been mapped by a medium-intensity soil survey. Lands within the national forest boundaries have been mapped by a low-intensity soil survey suitable for reconnaissance use. Of the 167,578 acres mapped with the medium-intensity soil survey, nearly 124,500 acres are classified in Land Use Capability Classes II through VI.

These 124,500 acres are the lands which have the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, and IV are suited for either cropland or urban uses, and Class VI has potential for urban developments.

The Deschutes River is one of the very smallest rivers in the Puget Sound Area. It drains an area of 287 square miles and has no major tributaries.

The Deschutes Basin provides the third smallest valley system in the Puget Sound Area. The system includes many flood and drainage problem areas which require corrective measures before their potential may be attained. The lower flood plain contains about 3,000 acres of level or gently undulating river bottom lands. Above the city of Tenino, the Basin is composed of rough, mountainous valleys with turbu-

lent streams. Most of the farm land sits above the flood plain on glaciated terraces.

Production

Forestry and farming are the main users of land in the Basin. Livestock raising is the most common and valuable farm industry. Dairying, berry growing, and poultry raising also play an important part in the economic welfare of the area. Total value of farm production is almost $5 million annually.

Forestry, including logging, lumbering, and the production of related products, is probably the major industry and several mills are located within the boundaries of the Basin.

Flooding

The topography and climate of the Deschutes Basin are such that only one flood-producing season occurs annually. This flood season is the result of excessive precipitation and usually occurs during the fall and winter seasons. The lack of high mountains prevents the accumulation of snow and thus does away with the early summer floods coming in other basins.

Rainfall in excess of channel capacity causes water to spread across the valley, where it remains until the river drops. In many areas, water is trapped by topographic detail until it can seep into the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV, Watershed Management. Principles and conditions discussed therein apply to the Deschutes Basin and need not be repeated here.

Watersheds

Three watershed areas requiring solutions to problems or development to achieve potential productivity of the Basin are shown on Land Use Map (Figure 7-36B) and on the Land Capability Map (Figure 7-37B).

The Deschutes River watershed (0-46) contains 60 percent of the forest land and 41 percent of the cropland of the Deschutes Basin. The upper portions of the watershed are hilly, forest-covered highlands with little or no population. Downstream from the town of Vail, there is considerable low-lying glacial outwash territory which contains most of the cropland. A portion of this type of country lying around Olympia is being urbanized at the present time. Future use would seem to be toward further urbanization with forestry continuing to play an important part.

Henderson Inlet watershed (0-47) provides the city of Olympia with all of its water supply. The source is McAllister Spring. This watershed also contains the big bulk of the Basin's cropland and built-up areas. Forest lands play an important part in the watershed's economy. Potential use seems to be in continued use as a water source area and in further urbanization.

West Budd Inlet watershed (0-48) has very little cropland or built-up areas. Much of the watershed is in forest. Potential use seems to lie in further development of forest lands with an increase in urbanization also looked for.

Many of the farm lands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions are summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the Deschutes Basin is shown in Table 7-46. The following tables are to indicate the potential development possible within acceptable land use standards.

Table 7-50 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-51 shows the number of acres in each capability class, subclass, and unit, by watersheds, in the Deschutes Basin. This table can be used with the description of capability units to estimate the potential for development.

TABLE 7-50. Distribution and value of production by crops in Deschutes Basin

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	243	249	1.53	12,015	1.03
Field crops	--	--	--	--	--
Vegetables	303	309	1.91	66,326	5.67
Berries	106	108	.67	111,113	9.51
Nursery products	86	88	.54	153,497	13.14
Cropland not used	1,340	1,371	8.43	--	--
Sub-Total	2,078	2,125	13.08	342,951	29.35
Hay	4,702	4,808	29.59	225,352	19.28
Hay aftermath	--	--	--	123,245	10.55
Sub-Total	4,702	4,808	29.59	348,597	29.83
Silage (grass)	676	691	4.25	45,782	3.92
Grass aftermath	--	--	--	17,714	1.52
Sub-Total	676	691	4.25	63,496	5.44
Silage (corn) fodder	94	96	.59	6,355	.54
Pasture (cropland)	8,340	8,528	52.49	407,113	34.84
Sub-Total	13,812	14,123	86.92	825,561	70.65
Total	15,890	16,248	100.00	1,168,512	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.

L E G E N D

LAND SUITED FOR CULTIVATION AND OTHER USES

I — Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II — Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III — Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

IV — Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

VI — Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

DESCHUTES BASIN
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

FIGURE 7-37B

TABLE 7-51. *Land capability units in Deschutes Basin (in acres)*[1]

Capability Units[2]	WATERSHEDS 0-46	0-47	0-48	Total
II ws 03	210	950	20	1,180
II ws 04	1,785	72	529	2,386
II ws 06	1,103	2,150	544	3,797
Class II Total	3,098	3,172	1,093	7,363
III es 02	15		40	55
III ws 01	434	902		1,336
III ws 02	15		178	193
III ws 05	973		97	1,070
III ws 08	110	301	46	457
III ws 09	472	66	26	564
III ws 10	566	1,767	475	2,808
III ws 12	421	3,552	516	4,489
III so 08	2,996	2,978	1,154	7,128
III sw 09			60	60
Class III Total	6,002	9,566	2,592	18,160
IV ew 14	15	5,738	825	6,578
IV ew 22	2,801	2,344	2,204	7,349
IV es 09	1,386	2,923	1,053	5,362
IV es 16	387	3		390
IV ws02	328			328
IV ws 05			15	15
IV ws 06	306	701	76	1,083
IV ws 09	536	153	307	996
IV ws 10	369			369
IV so 10	14,352	9,568	640	24,560
IV se 05	940	1,058	10	2,008
IV se 11	692	1,104	234	2,030
IV sw 09	949	1,612	896	3,457
Class IV Total	23,061	25,204	6,260	54,525
Class II-IV Total	32,161	37,942	9,945	80,048

[1] Does not include lands within national forest boundaries. Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

[2] See Exhibit 1 for description of capability units.

TABLE 7-51. Land capability units in Deschutes Basin (in acres)[1] (cont.)

Capability Units[2]	WATERSHEDS 0-46	0-47	0-48	Total
VI ew 21	591	2,170	824	3,585
VI es 18	313	432	7	752
VI es 19	1,698	4,126	1,287	7,111
VI es 20	947	481	279	1,707
VI es 21	120	575	959	1,654
VI es 25	2,630		490	3,120
VI so 01	794	1,203	275	2,272
VI so 18	2,238	5,334	1,272	8,844
VI so 19	810	849	279	1,938
VI so 21	767			767
VI se 15				40
VI se 17	3,084	7,010	2,084	12,178
VI se 21	306	145		451
Class VI Total	14,298	22,325	7,796	44,419
VII ew 30	63	616	316	995
VII es 29	4,930	826	534	6,290
VII es 33	185			185
VII es 36	30,113		3,575	33,688
VII so 23	938			938
Class VII Total	36,229	1,442	4,425	42,096
VIII ws 00	110	10	2	122
VIII ws 23		435	25	460
VIII ws 24	20	40	23	83
VIII so 00		310	40	350
Class VIII Total	130	795	90	1,015
Class V-VIII Total	50,657	24,562	12,311	87,530
Class II-VIII Total	82,818	62,504	22,256	167,578

1 *Does not include lands within national forest boundaries.* Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2 See Exhibit 1 for description of capability units.

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the Deschutes Basin will increase from 50,100 people in 1963 to about 100,400 by 2020, according to Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 27,957 acres presently in intensive and rural nonagricultural use could provide ample acreage for new intensive development to the year 2020 without encroachment onto the croplands of the Basin.

Cropland Needs

This Basin presently has 16,248 acres of cropland. Pressure from other uses is expected to reduce this figure to approximately 5,350 acres by 2020. Percent increases needed, by crops, for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Data in Table 7-52 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Deschutes Basin is summarized under the topic "Program Implementation" immediately following Forestry. A more complete description is found in Appendix XIV, Watershed Management.

TABLE 7-52. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	11,802[2]	11,802[2]	11,802
Watershed protection and rehabilitation[3]	acre	21,282	17,559	14,836
Drainage improvement	acre	1,738	2,897	3,863
Irrigation development[4]	acre	3,000	3,500	4,285
Water for irrigation[5]	ac.ft.	7,110	8,295	10,155

[1] A total of 31,892 acres in the Deschutes Basin are subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated here.

[2] Includes 3,723 acres expected to go to other uses by 2000 and 6,446 acres by 2020.

[3] Includes 9,480 acres of rangeland.

[4] According to Appendix VII, Irrigation, there were 2,700 acres (using 6,399 acre-feet of water) irrigated in 1966. Irrigation Appendix projections show 3,800 acres irrigated by 1980, 6,200 by 2000, and 10,000 acres by 2020.

[5] Based on gross diversion requirements of 2.37 acre-feet per acre, estimated by Irrigation Committee in Appendix VII, Irrigation.

FORESTS

PRESENT STATUS

A large part of the Nisqually-Deschutes Basins is forest covered with 80%, or 519,470* acres, classified as forest land (Table 7-53). Forests are located throughout the Basins except for several large prairies at lower elevations in the western portion. The larger areas of continuous forests are located in the higher elevations in the east half of the Basins. Six percent of the forest land, or about 30,000 acres, is held in reserved status primarily in Mount Rainier National Park. Classification of the remaining available forest land is shown by resource zones below:

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	167,750	34
Principal Forest	306,950	63
Upper Forest	14,960	3
Subalpine	300	0
Total available	489,960	100

*Does not include nonforested lands commonly associated with forest areas.

TABLE 7-53. Nisqually - Deschutes Basins—Area of forest land, in acres, by ownership and type.

Cover Type or Land Class	National Forest	Other Federal	State & County	Municipal	Indian	Private	Total Avail.	Unavailable	Total Avail. & Unavail.
	Available								
Douglas-fir									
seedlings and saplings	120	5,680	7,510	40	20	46,530	59,900	30	59,930
poletimber	300	18,980	19,500	140	440	122,610	161,970	430	162,400
small young growth sawtimber	11,340	2,340	8,060	50	40	27,990	49,820	910	50,730
old growth and large					--				
young growth sawtimber	10,200	8,970	9,230	40	--	56,460	84,900	2,600	87,500
True fir-mountain hemlock				--	--				
seedlings and saplings	30	--	--	--	--	2,560	2,590	420	3,010
poletimber	--	--	1,250	--	--	--	1,250	490	1,740
small sawtimber	2,240	--	--	70	--	300	2,540	2,870	5,410
large sawtimber	6,470	--	--			2,040	8,580	3,800	12,380
Western hemlock									
seedlings and saplings	70	--	610	30	--	5,130	5,840	140	5,980
poletimber	--	--	3,180	10	--	730	3,920	90	4,010
small sawtimber	1,440	--	--	--	--	3,260	4,700	640	5,340
large sawtimber	8,620	50	910	20	--	21,870	31,470	1,810	33,280
Western redcedar				--	--				
poletimber	--	--	--	--	--	4,180	4,180	-	4,180
small sawtimber	30	--	1,250	--	--	1,530	2,810	--	2,810
large sawtimber	140	--	--	--	--	330	470	--	470
Western white pine									
large sawtimber	--	--	--	--	--	510	510	--	510
White fir									
poletimber	--	--	--	--	--	--	--	340	340
large sawtimber	--	--	--	--	--	--	--	860	860
SUBTOTAL, softwoods	41,000	36,020	51,500	400	500	296,030	425,450	15,430	440,880
Hardwoods									
seedlings and saplings	--	190	300	--	--	3,010	3,500	160	3,660
poletimber	--	1,360	5,240	60	260	26,340	33,260	750	34,010
small sawtimber	170	--	40	10	--	14,040	14,260	40	14,300
large sawtimber	--	--	--	--	--	--	--	--	--
SUBTOTAL, hardwoods	170	1,550	5,580	70	260	43,390	51,020	950	51,970
Nonstocked									
cutover	130	--	2,090	--	--	7,140	9,360	--	9,360
deforested by fire	--	--	160	--	--	250	410	--	410
SUBTOTAL, nonstocked	130	--	2,250	--	--	7,390	9,770	--	9,770
TOTAL, productive land	41,300	37,570	59,330	470	760	346,810	486,240	16,380	502,620
Subalpine	300	--	--	--	--	--	300	10,020	10,320
Noncommercial, rocky	1,820	50	670	10	--	870	3,420	3,110	6,530
TOTAL, unproductive land	2,120	50	670	10	--	870	3,720	13,130	16,850
TOTAL, all forested land	43,420	37,620	60,000	480	760	347,680	489,960	29,510	519,470

The Nisqually-Deschutes Basins contain 486,240 acres of forest land capable of producing crops of raw material for the wood products industry. These lands have a sawtimber inventory of 8.1 billion board feet, International ¼-inch Rule (Table 7-54). This represents 9.7% of the Puget Sound Area's commercial forest land and 8.0% of its sawtimber volume. Private land accounts for 71% of the commercial forest area. Large corporate holdings make up 179,370 acres of the total, with the remaining 167,440 acres in small ownerships, such as farms, ranches, or other miscellaneous holdings. There are no medium sized ownerships. There are 139,430 acres of publicly-owned commercial forest land in the eastern and southern portions of the Basins. Ownership is 54% State and County, 38% National Forest, 7% other Federal, and 1% municipal and Indian land.

The forest products industry supported by the Nisqually-Deschutes Basins is concentrated at Olympia. Out of the 20 operating plants in 1964, fifteen were located at Olympia and Lacey. The remaining five manufacturing facilities are found at Alder, Eatonville, Graham, and Yelm. Industry grouping shows 13 plants are sawmills and planing mills, with one of the mills having a plywood plant, and seven are plywood and veneer plants. In the latter group, four produce hardboard. Raw materials needed by the industry amount to about one-half million board feet per day.

There are no severe problems affecting forest land management and development. The usual problems of access and intermingled ownership described for the Puget Sound Area are found throughout the Basins. Conversion to housing developments and small ranches and farms is making some inroads in the forest land base. Problems of the forest products industry are related to plant obsolescence and fluctuating markets as described in previous discussions of the Puget Sound Area.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

No determination of the demand for wood products is made specifically for the Nisqually-Deschutes Basins. The nature of the forest products industries, particularly the relative ease of log transportation between the Basins, would make such a determination rather meaningless. In addition, a specific figure would imply that a production goal was established for the Basins, which is not the case. Production goals are established for the Puget Sound Area as a whole, with the assumption that considerable shifts in production between the Basins will occur, depending upon the actual pattern of industrial and land use development.

For sake of basin comparison, however, there is some value in showing the percentage of demand that may be supplied by the Nisqually-Deschutes Basins in the future. In 2020, the Basins are expected to contain about 10% of the commercial forest land in the Puget Sound Area. The percentage in earlier periods is slightly lower. It is, therefore, assumed that the Basins will supply approximately 10% of the total wood products demand in the future.

The effect of competing uses for forest lands is discussed in detail in the section covering the Puget Sound Area. The estimated diversion of forest land from these causes in the Nisqually-Deschutes Basins is shown below:

Type of Land Diversion	Acres Diverted (2020)
Parks, Wilderness, Campgrounds, or other Recreation Use	2,390
Roads and Highways	15,140
Urban-Industrial Development	9,010
Reservoirs, Powerlines, and other miscellaneous conversion	1,000
Private Land Use Reservations	28,250
Total	55,790

TABLE 7-54. Nisqually-Deschutes Basins—Volume of sawtimber and growing stock, by ownership on productive land

	Available								
Species of Group	National Forest	Other Federal	State & County	Municipal	Indian	Private	Total Available	Unavailable	Total Available & Unavailable
Sawtimber—thousand board feet, International ¼-inch Rule									
Douglas-fir									
small sawtimber	166,160	65,700	150,280	990	1,130	584,780	969,040	13,790	982,830
large sawtimber	557,530	449,870	513,150	2,370	670	3,069,800	4,593,390	128,580	4,721,970
True fir—mountain hemlock									
small sawtimber	38,580	--	1,910	--	--	6,290	46,780	46,480	93,260
large sawtimber	397,740	--	1,920	3,790	--	122,400	525,850	191,680	717,530
Western hemlock									
small sawtimber	21,350	--	4,320	30	--	50,560	76,260	101,460	177,720
large sawtimber	451,670	2,460	51,850	1,110	--	1,110,890	1,617,980	90,340	1,708,320
Western redcedar									
small sawtimber	620	--	19,880	--	--	29,750	50,250	--	50,250
large sawtimber	12,530	--	--	--	--	25,930	38,460	--	38,460
Other softwood species									
small sawtimber	--	--	--	--	--	--	--	510	510
large sawtimber	--	--	--	--	--	26,510	26,510	45,220	71,730
SUBTOTAL, softwoods	1,646,180	518,030	743,310	8,290	1,800	5,026,910	7,944,520	618,060	8,562,580
Hardwoods									
small sawtimber	1,740	1,080	5,790	140	260	162,490	171,500	1,350	172,850
large sawtimber	--	1,080	5,380	50	260	25,560	32,330	920	33,250
SUBTOTAL, hardwoods	1,740	2,160	11,170	190	520	188,050	203,830	2,270	206,100
TOTAL SAWTIMBER all species	1,647,920	520,190	754,480	8,480	2,320	5,214,960	8,148,350	620,330	8,768,680
Growing Stock—Million Cubic Feet									
Douglas-fir	131.8	93.9	120.9	0.6	0.3	665.7	1,013.2	25.9	1,039.1
True fir-mountain hemlock	78.9	--	0.7	0.7	--	23.3	103.6	43.1	146.7
Western hemlock	92.2	0.5	10.9	0.2	--	226.3	330.1	37.4	367.5
Other softwood species	2.6	--	3.9	--	--	16.0	22.5	8.9	31.4
SUBTOTAL, softwoods	305.5	94.4	136.4	1.5	0.3	931.3	1,469.4	115.3	1,584.7
Hardwoods	0.7	0.9	4.4	0.1	0.2	74.3	80.6	0.9	81.5
TOTAL GROWING STOCK, all species	306.2	95.3	140.8	1.6	0.5	1,005.6	1,550.0	116.2	1,666.2

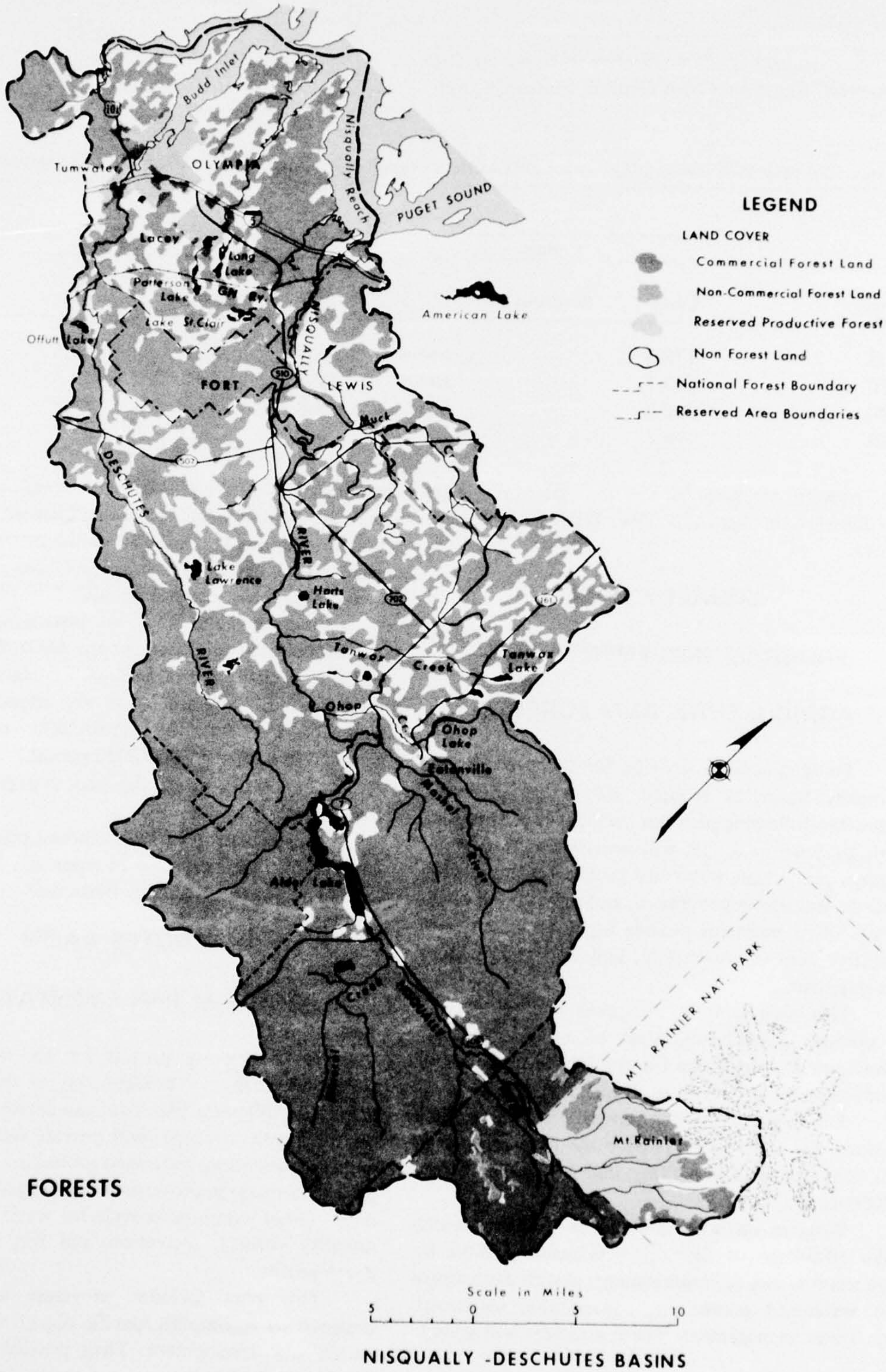


FIGURE 7-38. Forest lands in the Nisqually-Deschutes Basins

The current and prospective changes in the commercial forest land base from all causes are given below:

Current and projected commercial forest area in the Nisqually-Deschutes Basins 1965-2020 (in thousand acres)

	Ownership						
	Private			Public			
Period	Large	Medium	Small	NF	Other Federal	Other	Total
1965	179.3	--	167.4	41.3	37.6	60.6	486.2
1980	183.1	--	152.6	40.7	37.2	59.8	473.4
2000	192.8	--	125.5	39.8	36.7	58.9	453.7
2020	196.1	--	101.3	38.9	36.3	57.9	430.5

Specific measures for soil and water protection are discussed in Appendix XIV, Watershed Management.

NISQUALLY BASIN

PROGRAM IMPLEMENTATION

AGRICULTURE AND FORESTS

To satisfactorily provide for the needs in the Nisqually Basin, as brought out in the preceding pages, the following plan has been devised. This plan, multi-purpose in scope, will provide for floodwater damage prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development. Other measures provide for water quality and quantity control, recreation, and fish and wildlife development.

This plan contains programs and projects to accomplish specific objectives of conservation and development. It provides for the full development of lands expected to remain in cropland by 2020.[1]

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000); and (c) distant future (2000-2020).

Program measures are on-site practices which take advantage of developments made possible by structural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management, and irrigation development. Total cost of the program for the early action period is $16,371,000. No projects are included in the early action phase of the plan.

Four projects, with an installation cost of $2,930,000, are proposed for the 1980-2000 period, and one project to cost $100,000 is planned for the final period. Program costs are expected to be $24,303,000 for the 1980-2000 period and $24,586,000 for the 2000-2020 period.

The total cost of the plan is expected to be $68,290,000.

A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, Watershed Management, Nisqually Basin section.

DESCHUTES BASIN

PROGRAM IMPLEMENTATION

To sufficiently provide for the needs in the Deschutes Basin, as brought out in the preceding pages, the following plan has been devised. This plan, multi-purpose in scope, will provide for floodwater damage prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development. Other measures provide for water quality and quantity control, recreation, and fish and wildlife development.

This plan includes programs and projects designed to accomplish specific objectives of conservation and development. They provide for the full development of lands expected to remain in cropland

[1] Approximately 20,000 acres will be lost to other uses by 2020.

by 2020. Approximately 11,000 acres will be lost to other uses by 2020.

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000); and (c) distant future (2000-2020).

Program measures are on-site practices which take advantage of developments made possible by structural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management, and irrigation development. Total cost of the program for the early action period is $6,426,000. No projects are proposed for the early action period.

Three projects with an installation cost of $1,410,000 are planned for the 1980-2000 period. No projects are planned for after the year 2000. Program costs are expected to be $9,040,000 for the 1980-2000 period and $8,748,000 for the 2000-2020 period. Total cost of the plan is expected to be $25,624,000.

A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, Watershed Management, Deschutes Basin section.

MINERALS

Clay and sand and gravel are the most important minerals mined in the Nisqually Basin. Other minerals that have been or are being produced in the area are coal, mineral water, stone, copper, and iron. Mineral deposits that occur in the area, but which have not as yet been developed, are peat, perlite, silica, diatomite, and gold.

The locations of the known mineral deposits in the Basins are shown on Figure 7-39. The open circles on the maps indicate properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

NISQUALLY BASIN

Clay

Four clay deposits have a record of production. Three of these contain common clay that has been used to make clayware such as brick, tile, and pottery. Only one deposit is currently active—Builders Brick Co.'s pit at Clay City.

A fourth deposit, near LaGrande, consists of refractory clay. It was mined years ago by the Denny-Renton Clay and Coal Co.

No production figures or estimate of common clay reserves are available. The refractory clay deposit at LaGrande has estimated reserves of 7,000 yards.

Coal

The Ashford coal seams are in sedimentary rocks of the Puget Formation, but their stratigraphic relation to other coalbeds to the north is unknown. The beds have been folded and faulted, and it is not unusual to find coal seams pitching more than 60°. Production has been limited; only about 1,000 tons of coal has been mined. Reserves are estimated at 13 million tons.

Peat

Thirteen peat bogs have been investigated. Three of the bogs contain sphagnum peat. No peat is currently being produced from the Nisqually area.

Sand and Gravel

Several large, high-quality gravel deposits occur. Aggregate, fill, and crushed rock have been produced from more than 50 pits. Currently, sand and gravel is being produced from only one pit, and most of its production is being exported to the White-Puyallup Rivers drainage system.

Production figures are not available for publication, and no quantitative estimate of reserves has been made other than they are adequate at the present rate of consumption.

Stone

There are five stone quarries—three in andesite and two in granite. The two andesite properties, both near Eatonville, are currently (1966) producing land-

scape rock and rubble. Production statistics are not available for publication. Reserves are sufficiently large to last for a considerable time.

Mineral Water

The Longmire Springs (Figure 7-39) are within the boundary of Mount Rainier National Park. The temperature of the spring waters ranges from cold to hot, and the waters vary in mineral content from carbon dioxide to a sulfur-iron mixture. A hotel is located at the springs.

Copper

The Eagle Peak mine (Figure 7-39, No. 107) had a reported production of 100 tons in 1919 and unknown amounts in 1925 and 1928. Total production has probably been less than 200 tons. The deposit is in mineralized joints or slip planes in granite. One zone ranges from 6 inches to 5 feet in width. One 18-ton shipment contained 8.05 percent copper, 0.09 ounce of gold, and 1.87 ounces of silver per ton.

A reported 40-ton shipment was made from the Paradise mine (Figure 7-39, No. 107A) prior to 1921. The deposit is in a mineralized slip plane in andesite that carries 4 to 8 inches of ore. The only shipment made is reported to have assayed 10 percent copper.

A copper property known as the Mashel (Figure 7-39, No. 107) is reported to have shipped copper around 1900. The deposit is an altered volcanic rock with thin seams of native copper along joint planes.

Iron

A small amount of bog ore was mined at St. Clair Lake (Figure 7-39, No. 105) for use as a mineral pigment. The deposit contains roughly 7,600 tons of bog ore. One analysis showed 54.05 percent Fe_2O_3, 14.90 percent SiO_2, 7.50 percent Al_2O_3, 2.80 percent organic matter, and 18.20 percent moisture.

Other Mineral Deposits

There are two diatomite deposits, one silica deposit, one perlite deposit, and one gold deposit in the Basin. None of these properties have had development work or production.

A test shipment from the Copper King (Figure 7-39, No. 98) was made in 1918, and the Surprise mine (Figure 7-39, No. 99) had a similar shipment in 1919.

Gold

Prior to 1945, the Silver Creek mine (Figure 7-39, No. 102) made shipments of 100 tons of ore that ran more than $50 per ton. The ore deposit is an altered silicified andesite mineralized along narrow joints.

The Silver Creek Gold & Lead mine (Figure 7-39, No. 100) reported 20 tons shipped in 1945 that ran $89.75 per ton. The ore is in a rhyolite cut by a fault zone 1 to 4 feet wide containing limy gouge and bands of quartz with sulfides.

At the Washington Cascade mine (Figure 7-39, No. 103) 5 tons were produced in 1936 and 30 tons in 1938. Return on the 30 tons was $180. The ore deposit is a 5-foot vein in andesite.

The Silver Creek gold placer (Figure 7-39, No. 101) reported returns of about $1.25 per yard over a 10-year period (1920-30). Total production values are not available.

Zinc

The only zinc property, the Golden Rule, has had no production.

DESCHUTES BASIN

Sand and gravel, stone, peat, and mineral water have been produced from the Deschutes Basin. No other mineral commodities have been found in sufficient quantity to have stimulated serious investigation.

Sand and Gravel

Sand and gravel is being produced actively from two pits and intermittently from another pit. Several other pits in the area have been active and upon rare occasions are reactivated for special uses (these are owned and used mostly by Thurston County).

Production statistics are not available for publication. Sand and gravel reserves are adequate for many years at the present rate of production.

Stone

Stone has been produced from three quarries. Two quarries are in basalt, and the third is in gabbro. All three quarries have been worked within the past few years and will continue production in the future as needed.

Stone production statistics are not available for

publication. Reserves appear to be adequate for several years' use.

Peat

Fifteen peat bogs totaling 1,278 acres have been investigated. Six bogs contain sphagnum peat, and two of them are being actively mined. Production figures are not available for publication. The area has substantial reserves.

Mineral Water

Years ago, mineral water from the Olympia Hygeian Spring, in Tumwater, was bottled and sold for table use. Production was discontinued many years ago. No estimate of the amount of water sold is available.

INTENSIVE LAND USE

The Nisqually-Deschutes Basins' crescent-shaped area extends from the southern tip of Puget Sound to the base of Mount Rainier National Park, covering portions of Pierce, Thurston and Lewis Counties. The area's economy is centered around lumbering and production of wood products, and State government activities. Much of the best lands in the Basins are along the rivers in the uplands near Olympia. Most of the cultivated land is used to produce feed for dairy cattle and poultry. A substantial portion of the lower Nisqually Basin is occupied by the Fort Lewis Military Reservation.

Intensive land uses in Nisqually-Deschutes Basins are found primarily around Olympia, located at the southern terminus of Puget Sound. Of the 635,594 acres of land in the Basins, some 19,897 are currently being intensively used. There are seven incorporated municipalities and approximately seven unincorporated places.

INCORPORATED CITIES AND TOWNS

Olympia

The city of Olympia, situated at the head of the Budd Inlet on the extreme southern end of Puget Sound, is the State Capitol and county seat of Thurston County. Initial settlement began in 1846, and the townsite was platted in 1850, designated the capitol of the newly-created Washington Territory in 1853, and incorporated in 1859.

In 1950, Olympia's population was 15,819; and in 1967, 20,880, including a small area annexed in 1967.

The Port of Olympia is a port of entry and is equipped to handle any cargo, local freight, and large ocean vessels. The deep water Olympia Harbor has a Reserve Fleet of over 100 merchant ships under the jurisdiction of the Maritime Administration of the U.S. Department of Commerce.

State government is the primary source of the city's income, but strong industries are lumber, wood products, food, beverages, and cultivation and processing of the Olympia oyster. The 249-acre Priest Point Park, site of an early Catholic mission to the Indians, is within the city limits on the Sound to the north.

Lacey

The city of Lacey, situated northeast of Olympia, was incorporated December 1966, and had a 1967 population of 7,650. Many of Lacey's residents are State employees or are otherwise employed in Olympia.

Tumwater

The city of Tumwater borders Olympia on the south and is situated on the Deschutes River. According to Washington history, Tumwater was the first American settlement north of the Columbia River (1845) and was the Puget Sound terminus of the northern extension of the Oregon Trail, later known as the Cowlitz Trail. At Deschutes Falls in 1845-47, was built the first grist mill and sawmill on the Sound, and the town was incorporated in 1875. Today, Tumwater's only large industry is the Olympia Brewing Company.

Tumwater has grown steadily, largely due to its proximity to Olympia. A 1950 population of 2,725 had increased by 1967 to 4,698.

Yelm

The city of Yelm continues to grow due to growth of State government offices in Olympia and the Fort Lewis Military complex. Located in south-

MINERAL PROPERTIES IN NISQUALLY-DESCHUTES BASINS*

Explanation for Figure 7-39

Metallic Minerals
(with production or reserves data where available)

Copper (3 properties)
- 107 – Eagle Peak (prod. less than 200 tons)
- 107A – Paradise (prod.–40 tons)
- 106 – Mashel

Gold (1 property)

Iron (1 property)
- 105 – St. Clair Lake (reserves–7,600 tons)

Stone Deposits

Granite (2 properties)

Volcanic rock (6 properties)

Nonmetallic Minerals
(with reserves data where available)

Coal (reserves–13.41 million tons)

Common clay (3 properties
- 89 – Bean
- 89A – Builders Brick
- 88 – Gail Sigford Pottery

Diatomite (1 property)

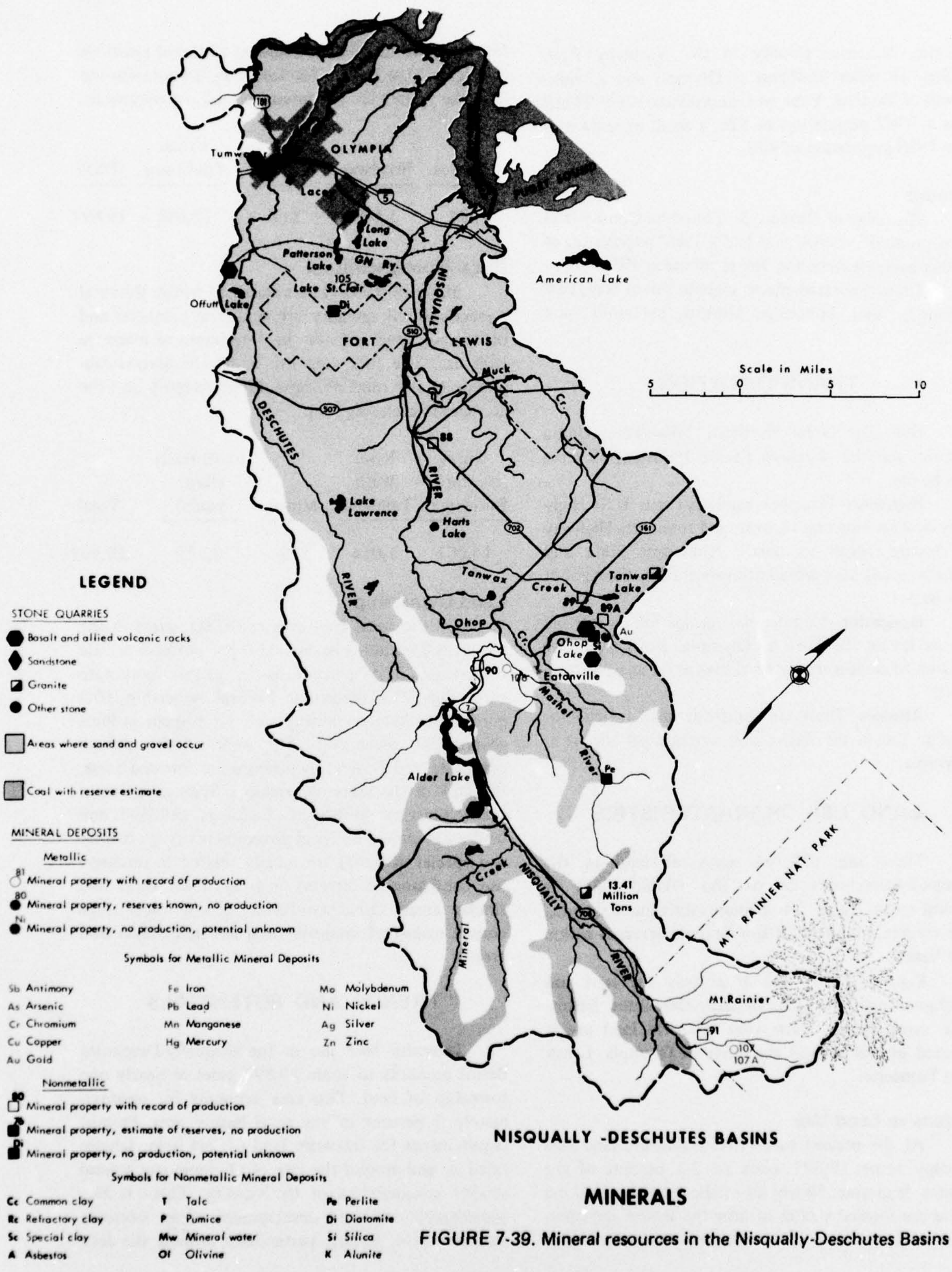
Mineral water (2 springs)
- 91 – Longmire Springs
- 87 – Olympia Hygeian Springs

Perlite (1 property)

Refractory clay (1 property)
- 90 – LaGrande

Silica (1 property)

*Some properties not plotted on map because of poor description of location and/or lack of space.



NISQUALLY -DESCHUTES BASINS

MINERALS

FIGURE 7-39. Mineral resources in the Nisqually-Deschutes Basins

eastern Thurston County in the Nisqually River Valley 18 miles southeast of Olympia and 25 miles south of Tacoma, Yelm was incorporated in 1924 and has a 1967 population of 525, a small increase over the 1950 population of 470.

Tenino

The city of Tenino in Thurston County was incorporated in 1906 and had a 1967 population of 880, a decrease from the 969 residents in 1950.

Unincorporated places include South Bay, East Olympia, Vail, McKenna, Mineral, LaGrande, and Alder.

TRANSPORTATION

Rail–The Great Northern, Milwaukee, Union Pacific, and the Northern Pacific Railroads all serve the Basins.

Highways–Principal roadways are U.S. Highway 410 running east to west, and Interstate Highway 5 running south to north. Numerous State and county roads also provide transportation throughout the Basins.

Navigation–Commercial navigation is carried on as far as the Port of Olympia. Both rivers are limited to certain recreational uses as far as navigation goes.

Airways–There are numerous small airfields for civilian use in the Basins and a municipal airport at Olympia.

LAND USE CHARACTERISTICS

There are 635,594 acres of land in the Nisqually-Deschutes Basins and 10,065 acres of inland water. Table 7-46 contains the figures showing the various amounts of major land use acreages within the Basins.

Figures 7-36A and B portray the land use configurations for the Nisqually-Deschutes Basins. The maps clearly show that intensive land use is located in and around the cities of Olympia, Lacey and Tumwater.

Intensive Land Use

At the present time (1967) intensive land uses occupy some 19,897 acres or 3.1 percent of the Basins' land area. Nearly all of the intensive land use areas are located within or near the Basins' incorporated and unincorporated communities, although a few intensive uses will be found at scattered locations throughout the Basins. The following list contains the land use figures for the intensive land use subgroups.

Railroads	Roadways	Airports	Urban (Built-up)	Total
1,623	5,099	517	12,658	19,897

Rural Nonagricultural

Many of the land uses classified within the rural nonagricultural category are similar in character and often associated with or the forerunner of intensive land use. The following list shows the several subgroups in the rural nonagricultural category and the acreages in each subgroup.

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm yards)	Total
14,001	1,014	519	4,375	19,909

Land Ownership

Of the total land area (635,000 acres) in the Nisqually-Deschutes Basins, 35.6 percent is in private ownership, 31.5 percent is in private corporate ownership, 21.6 percent in Federal ownership, 10.2 percent in State ownership, and 1.1 percent in local government ownership. The bulk of the private corporate and Federal ownerships are forested areas; the bulk of the State ownership is State government and military establishments, buildings, and land; and land areas owned by local governments (city, county and special districts) are mainly related to intensive use consisting of streets, facilities, local parks and similar areas. Other nonforest, private ownerships consist mainly of intensive rural nonagricultural land areas.

TRENDS AND POTENTIALS

Intensive land use in the Nisqually-Deschutes Basins amounts to some 19,897 acres or nearly one township of land. This area accounts for approximately 3 percent of the total Basins' area. Present requirements for intensive land use are being largely filled in and around the city of Olympia and several smaller communities in the vicinity. There is also considerable scattered development of an intensive nature in the Basins, particularly around the lake

shores and along the shores of Puget Sound. Nearly all of the intensive land use is located in the Deschutes River portion of the Basins. Within the Nisqually-Deschutes Basins there are approximately seven (7) townships comprising some 161,000 acres which are considered most likely to receive pressures for intensive use purposes. These townships are mainly located in the vicinity of the city of Olympia and to the south and west of the Fort Lewis Military Reservation.

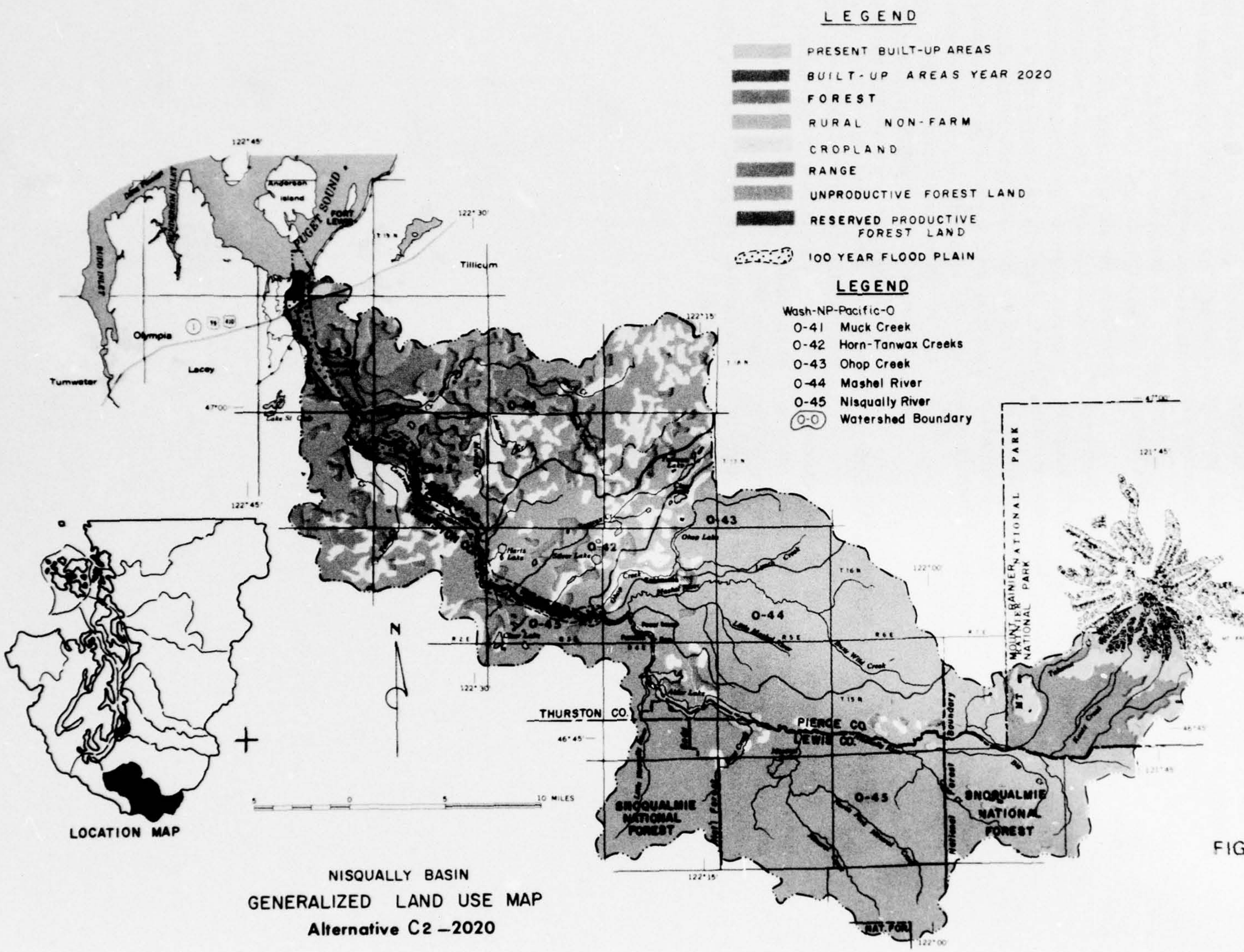
A potential for development of a deep-water port and industrial complex exists on the Nisqually flats at the mouth of the river. Preliminary investigations are now underway examining the feasibility of such a development. Present freeway construction across the Nisqually flats has distracted from the total potential of such a development.

PRESENT AND FUTURE NEEDS

Present trends in the Nisqually-Deschutes Basins reveal that the intensive land use is filling in and around the city of Olympia and several of the smaller communities. A large part of this is primarily new residential development to serve the increasing numbers of persons employed by State government in Olympia, plus the continual build-up of personnel at Fort Lewis which has brought a large number of people into the Basins. State government employment will continue to increase with a large increase coming after 1970 with the creation of Evergreen State College in Olympia.

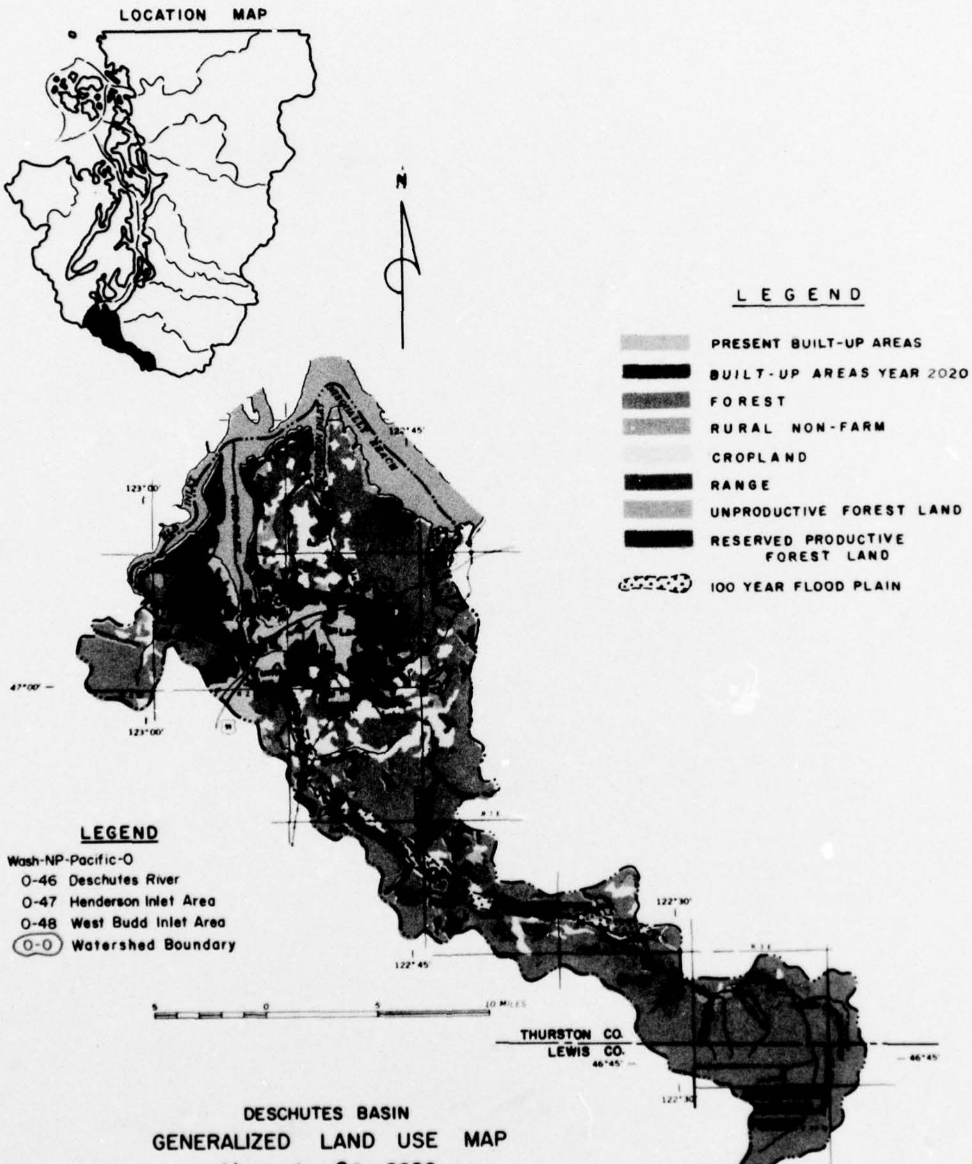
An examination of the Basins reveals that there are some 161,000 acres that are most likely to receive pressures for intensive land use purposes. With a population density of about 6 persons per acre and a population projection of 146,500 persons by the year 2020, there will be a requirement for only 23,500 acres to meet the needs in the Basins. A highly selective process should be forthcoming to assure that the conversion of land to intensive uses will not be overly detrimental to other land uses in the Basins. Each use will be put on those lands best suited for that use. Figures 7-40A and B portray the projected future land use pattern (C_2) for the Nisqually-Deschutes Basins for the year 2020.

If a major deep-water port facility is developed at the mouth of the Nisqually River, then land use figures for the Basins will need to be re-evaluated, plus the land use plan for the area will have to be updated.



NISQUALLY BASIN
GENERALIZED LAND USE MAP
Alternative C2 –2020

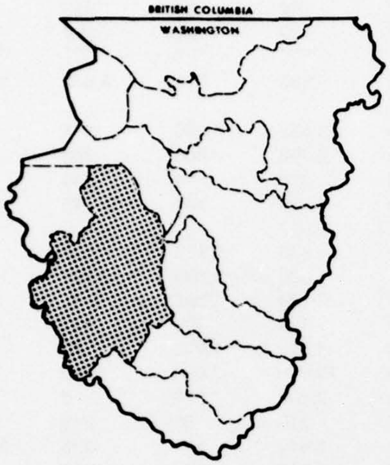
FIGURE 7-40A



DESCHUTES BASIN
GENERALIZED LAND USE MAP
Alternative C2 –2020

FIGURE 7-40B

WEST SOUND BASINS



The West Sound Basins are located in the west sector of the Puget Sound Area including the Kitsap Peninsula and the eastern part of the Olympic Peninsula. Portions of Pierce, Thurston, King, Grays Harbor, Mason, Jefferson, and Clallam Counties and all of Kitsap County are included in this area. All of the important drainage areas flow into Hood Canal. These include the Big and Little Quilcene, Dosewallips, Duckabush, Tahuya, Hamma Hamma, and Skokomish Rivers. The hydrologic area of 1,293,993 acres in the West Sound Basins contains a great variety of resources and economic environment which ranges from a metropolitan complex with a major naval base, through pioneer ranch type land use and from tidelands to high mountain country. The area also includes 13 islands, over 300 acres in size, which are situated within the saltwater reaches of Puget Sound.

Population

The population of the Basins in 1967 was 134,200 persons. Projections show that the population will increase to 175,000 by 1980, 274,100 by the year 2000, and 432,700 persons by the year 2020. If a cross-sound bridge is constructed after 1980, the population will swell to over 632,700 persons by 2020.

Land Use

The principal land use in the West Sound Basins is forests and associated lands which make up 88% of the total. The other two primary land uses, croplands and urban or built-up, occupy 4% and 3%, respectively. Table 7-55 shows the tabulation of present land use within the Basins. Figure 7-41, the generalized land use map of the West Sound Basins, portrays the land areas occupied by each of the major uses.

AGRICULTURE

PRESENT STATUS AND POTENTIAL

The West Sound Basins include all of Kitsap County and parts of Clallam, Jefferson, Mason, Thurston, Pierce and King Counties. The Basins include some islands and the land on the peninsula, with the exception of the Elwha-Dungeness Basins.

The western part of the area is mountainous, as the boundary is the crest of the coast range and the Olympic range of mountains. The remainder of the area shows evidence of major glaciation and is gently rolling, with somewhat poorly-developed drainage in some areas.

Of the total land area of 1,281,387 acres in the Basins, those lands outside the national forest and park boundaries have been mapped by a medium-intensity soil survey. Lands within the national forest and park boundaries have been mapped by a low-intensity soil survey suitable for reconnaissance use. Of the 915,515 acres mapped by the medium-intensity soil survey, approximately 772,259 acres are the lands which have the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, and IV are suited for either timber, cropland, or urban use, and Class VI has potential for timber or urban development.

TABLE 7-55. Land use in West Sound Basins (acres)[1]

Map No.	Watershed	Crop-land	Range-land	Total Forests[2]	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
0-56	S. Fork Skokomish R.	1,900	40	79,607	80	294	313	82,234
0-57	N. Fork Skokomish R.	70	40	69,199	450	82	4,355	74,196
	Sub-Total Skokomish R.	1,970	80	148,806	530	376	4,668	156,430
0-49	Skookum Creek	3,363	200	46,160	3,532	1,046	531	54,832
0-50	Isabella Creek	821		18,019	2,256	806	338	22,240
0-51	Anderson Island	607		4,205	216	4	143	5,175
0-52	McNeil Island	1,268		2,760	88	101	115	4,332
0-53	Hartstene Island	450		11,530	1,617			13,597
0-54	Goldsborough Creek	907	89	34,599	370	2,536	274	38,775
0-55	N.W. Shelton	1,724	130	90,409	8,639	1,699	2,421	105,022
0-58	West Hood Canal			27,938	2,188	282	177	30,585
0-59	Tahuya River	70		27,237	794	198	491	28,790
0-60	North Hood Canal	621		28,170	2,815	1,233	362	33,201
0-62	Carr Inlet Area	4,287	460	60,524	10,616	3,933	389	80,209
0-63	Vashon Island	3,870	543	15,368	2,400	918	6	23,105
0-66	Hamma Hamma River			59,096	310	58	248	59,712
0-67	Dosewallips-Duckabush	241	8	144,111	1,642	131	275	146,408
0-68	East Hood Canal	178		51,267	1,953	443	328	54,169
0-69	West Kitsap Area	4,649	386	53,216	4,861	13,226	483	76,821
0-70	East Kitsap Area	7,614	1,138	68,242	10,907	7,219	527	95,647
0-71	Quilcene	967	55	75,088	1,335	200	225	77,870
0-72	East Jefferson	3,667	1,197	109,185	5,578	6,539	463	126,629
0-73	Chimacum	4,257	226	16,981	398	464	108	22,434
0-75	Sequim Bay Area	745	15	20,906	637	156	23	22,482
0-76	Johnson Creek	3,939	610	9,849	526	593	11	15,528
	Sub-Total other Pacific Drainages	44,245	5,057	974,860	63,678	41,785	7,938	1,137,563
	West Sound Basins	46,215	5,137	1,123,666	64,208	42,161	12,606	1,293,993

[1] Unadjusted measurements, 1966, for Puget Sound Area Study.

[2] Figures include nonforested land commonly associated with forest areas.

The Skokomish River is the largest river system in the Basins. It drains an area of 244 square miles. Smaller rivers within the Basins are the Quilcene, Dosewallips, Duckabush and Hamma Hamma Rivers, all of which originate in rough mountainous country and empty into the Hood Canal arm of Puget Sound. The Kitsap Peninsula and the islands within the Basins are drained by small streams with lower gradients. The Basins include many flood and drainage problem areas which require corrective measures to attain their potential. Presently, about 46,000 acres are devoted to farming, with a potential total of about 120,000 acres of Class II and III lands which could be used for this purpose.

Production

Farming is important to the area, with a substantial dairy industry and a large grape industry as the main dollar volume items. Total value of farm production in the West Sound Basins is over $4.5 million annually. Forest products are likely to continue to be the largest basic industry in the area.

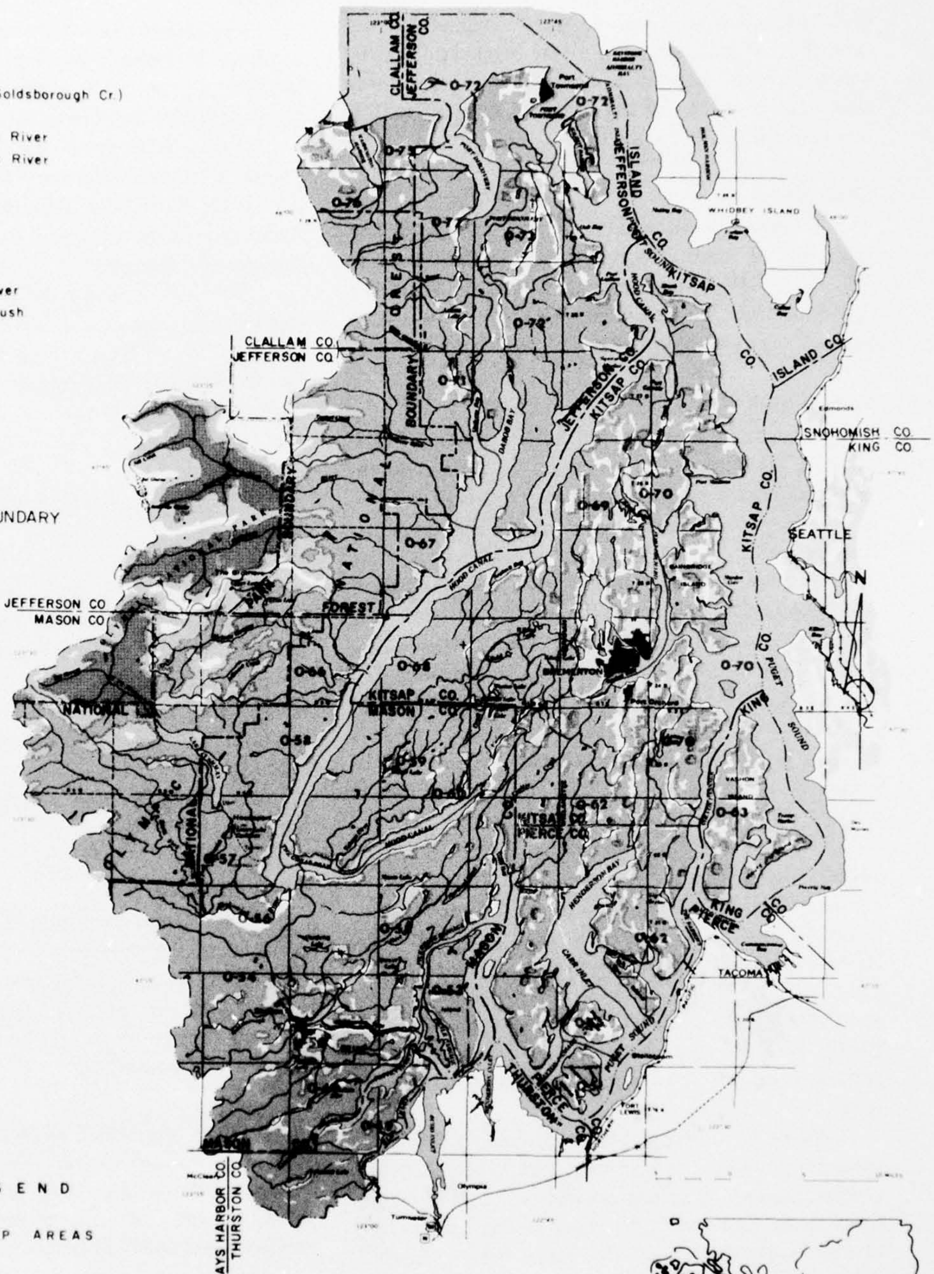
Flooding

The rivers which originate in the high mountain country of the Olympic range have two flood-producing seasons annually. However, the major damage occurs on the Skokomish, as the Hamma Hamma and other rivers are largely undeveloped

LEGEND

Wash-NP-Pacific-O

- 0-49 Skookum Creek
- 0-50 Isobella Lake
- 0-51 Anderson Island
- 0-52 McNeil Island
- 0-53 Horstene Island
- 0-54 West of Shelton (Goldsborough Cr.)
- 0-55 N. W. Shelton
- 0-56 S. Fork Skokomish River
- 0-57 N. Fork Skokomish River
- 0-58 W. Hood Canal
- 0-59 Tahuya River
- 0-60 N. Hood Canal
- 0-62 Carr Inlet Area
- 0-63 Vashon Island
- 0-66 Hamma Hamma River
- 0-67 Dosewallips-Duckabush
- 0-68 E. Hood Canal
- 0-69 West Kitsap Area
- 0-70 East Kitsap Area
- 0-71 Quilcene
- 0-72 East Jefferson
- 0-73 Chimacum Creek
- 0-75 Sequim Bay Area
- 0-76 Johnson Creek
- (0-0) WATERSHED BOUNDARY



LEGEND

- BUILT-UP AREAS
- FOREST
- RURAL NON-FARM
- CROPLAND
- RANGE
- UNPRODUCTIVE FOREST LAND
- RESERVED PRODUCTIVE FOREST LAND
- GRASS, BRUSH, & BARRENS

LOCATION MAP

FIGURE 7-41

WEST SOUND BASINS

GENERALIZED LAND USE MAP

areas. The streams which start at lower elevations, such as Chimacum Creek and the Quilcene River, are subject to floodflows from severe storms during the winter months. Low areas along streams are covered with water which usually remains trapped in low areas even after the river drops.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV, Watershed Management. Principles and conditions discussed therein apply to the West Sound Basins and need not be repeated here.

Watersheds

Twenty-four watershed areas requiring solutions to problems or development to achieve potential productivity of the Basins are shown on Land Use Map (Figure 7-41) and on the Land Capability Map (Figure 7-42).

Skookum Creek (0-49); Northwest Shelton (0-55); South Fork Skokomish (0-56); Carr Inlet Area (0-62); Vashon Island (0-63); West Kitsap Area (0-69); East Kitsap Area (0-70); East Jefferson (0-72); Chimacum (0-73); Sequim Bay Area (0-75); and Johnson Creek (0-76); are the watersheds with the greatest potential for agricultural or urban development, as they contain 65 percent of the Class II through Class IV lands in the entire area.

The remainder of the designated watersheds, Isabella Creek (0-50); Anderson Island (0-51); McNeil Island (0-52); Hartstene Island (0-53); Goldsborough Creek (0-54); North Fork Skokomish (0-57); West Hood Canal (0-58); Tahuya River (0-59); North Hood Canal (0-60); Hamma Hamma River (0-66); Dosewallip-Duckabush Rivers (0-67); East Hood Canal (0-68); and the Quilcene River (0-71) have a high potential for forest products, and as water source areas.

Many of the farm lands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions are summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the West Sound Basins is shown in Table 7-55. The following tables are to indicate the potential development possible within acceptable land use standards.

Table 7-56 shows the relative importance of groups of crops within the farming sector of agriculture at the Basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-57 shows the number of acres in each capability class, subclass, and unit, by watersheds, in the West Sound Basins. This table can be used with the description of capability units to estimate the potential for development.

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the West Sound Basins will increase from 134,200 in 1967 to approximately 399,600 by 2020, based on Regional Economic Studies Technical Committee data. At a density of six persons per acre the 106,369 acres presently in intensive and rural nonagricultural use will provide ample acreage for new intensive development through the year 2020 without an encroachment onto the croplands of the Basins.

Cropland Needs

The Basins presently have 46,215 acres of cropland. A slight decrease in this acreage is expected for each time period, therefore, cropland in 2020 is expected to be about 40,000 acres. The percent increases needed by crops, for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Data in Table 7-58 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

TABLE 7-56. Distribution and value of production by crops in West Sound Basins

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	190	254	.55	12,247	.28
Field crops	55	73	.16	21,799	.49
Vegetables	664	887	1.92	190,384	4.28
Berries	804	1,073	2.32	1,104,468	24.79
Nursery products	302	403	.87	702,945	15.78
Cropland not used	2,867	3,828	8.28	--	--
Sub-Total	4,882	6,518	14.10	2,031,843	45.62
Hay	9,048	12,082	26.14	566,307	12.71
Hay aftermath	--	--	--	343,840	7.72
Sub-Total	9,048	12,082	26.14	910,147	20.43
Silage (grass)	2,345	3,132	6.78	207,500	4.66
Grass aftermath	--	--	--	87,909	1.97
Sub-Total	2,345	3,132	6.78	295,409	6.63
Silage (corn) fodder	354	473	1.03	31,335	.70
Pasture (cropland)	17,981	24,010	51.95	1,185,941	26.62
Sub-Total	29,728	39,697	85.90	2,422,832	54.38
Total	34,610	46,215	100.00	4,454,675	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.

TABLE 7-57. Land capability units in West Sound Basins (acres)[1]

Sheet 1 of 4

Line	Capability units 2/	WATERSHEDS 0-49	0-50	0-51	0-52	0-53	0-54	0-55	0-56	0-57	0-58	0-59	0-60
1	II ws 03	20							2,609	245	40		488
2	II ws 04	453	270				50		1,262	30	130		
3	II ws 06	474	411		55	66	882	2,522	481	138	530	89	
4	II sw 02												
5	II sw 03												
6	II TOTAL	947	681		55	66	932	2,522	4,352	413	700	89	488
7	III ew 01							2,570				2,837	926
8	III ew 03												
9	III es 02	2,191	459										
10	III we 17			196	322								
11	III ws 01	55	38				225	115	172	100		220	180
12	III ws 02	436											
13	III ws 03		25				100	55				149	10
14	III ws 04												
15	III ws 05	481	181				55	668				622	307
16	III ws 08	1					90	5					185
17	III ws 09	210	25		7	10	492	308		10	10	40	133
18	III ws 10	1,293	516	65	250	217	318	695			15		10
19	III ws 11												
20	III ws 12	657				19		115					65
21	III so 08	830											
22	III sw 09	717	60				355						
23	III TOTAL	6,871	1,304	261	579	246	1,635	4,531	172	110	25	3,868	1,816
24	IV ew 03	25		864		2,822		2,092					
25	IV ew 12			686									
26	IV ew 14	4,677	3,658			309	1,094	3,995			7	248	130
27	IV ew 22	2,440	654	590	2,177			48,236	2,113			11,984	10,989
28	IV es 09	6,853	4,195				11,421	495	1,644	125	485		335
29	IV es 10												
30	IV es 16	11											
31	IV ws 02	21											
32	IV ws 05			78									
33	IV ws 06	149	60	55		36	200	531	450	57	117	112	183
34	IV ws 08	20					74	45			5		17
35	IV ws 09	45	17				618	101			7		10
36	IV ws 10	30		579									
37	IV ws 12	170	130			292	91	315				30	25
38	IV ws 13												
39	IV ws 43												
40	IV so 01	163	30			1	79	297	63	221	50	45	
41	IV so 10	95											
42	IV se 05	179	105	10	522	253		1,026				145	1,090
43	IV se 10												
44	IV se 13												
45	IV sw 06					325							
46	IV sw 09	802									5		
47	IV TOTAL	15,680	8,849	2,862	2,699	4,038	13,577	57,133	4,270	403	676	12,564	12,779
48	II-IV TOTAL	23,498	10,834	3,123	3,333	4,350	16,144	64,186	8,794	926	1,401	16,521	15,083

TABLE 7-57. Land capability units in West Sound Basins (acres)[1] (continued)

Sheet 2 of 4

WATERSHEDS													Line
0-62	0-63	0-66	0-67	0-68	0-69	0-70	0-71	0-72	0-73	0-75	0-76	Total	
27		110	239									3.778	1
		5	116				818	645	195	72	85	4,131	2
584			35	129	315	1,113	122	1,117	1,389	62	62	10,576	3
							29	1,015	409	45		1,498	4
			18				2	105	42			167	5
611		115	408	129	315	1,113	971	2,882	2,035	179	147	20,150	6
2,471	220			12,335	12,537	20,276						54,172	7
								2,623	295	8,756	5,253	16,927	8
							261	479	81			3,471	9
1,919												2,437	10
		15	328	52			167					1,667	11
												436	12
			15	115			211	68				748	13
											1,046	1,046	14
609				986	3,070	1,991		118	5			9,093	15
370				45	696	733	113	651	446			3,335	16
364	89		63	10			542	1,001	332	7		3,653	17
707				22				5	187	166	356	4,822	18
							5	306	145			456	19
						145						1,001	20
												830	21
												1,132	22
6,440	309	15	406	13,565	16,303	23,145	1,299	5,251	1,491	8,929	6,655	105,226	23
5.532					485	1,993		7,736	900	298	35	22,782	24
659							15					1,360	25
85		25	20	25			551	1,895	69			16,788	26
16,024	15,758			10,780	16,333	11,960	1,210	4,232	1,740			157,220	27
				8								25,561	28
								63				63	29
					90	222						323	30
												21	31
												78	32
233	13			129	697	530	302	933	524			5,311	33
50				5	695	1,691						2,602	34
230												1,028	35
40	17						190	343	61		67	1,327	36
												1,053	37
								412	102	122	588	1,224	38
			23				123	515	170			831	39
				5	205	1,134		193	58	480	206	3,230	40
6											51	152	41
3.544	332		95	55			16	168				7,540	42
								389				389	43
	3											3	44
							77	17,654	1,729			19,785	45
							1,908	8,223	2,908			13,846	46
26,403	16,123	25	138	11,007	18,505	17,530	4,392	42,756	8,261	900	947	282,517	47
33,454	16,432	155	952	24,701	35,123	41,788	6,662	50,889	11,787	10,008	7,749	407,893	48

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include lands within national forest or park boundaries.

2/ See Exhibit 1 for description of capability units.

TABLE 7-57. Land capability units in West Sound Basins (acres)[1] (continued)

Sheet 3 of 4

Line	Capability units 2/	WATERSHEDS 0-49	0-50	0-51	0-52	0-53	0-54	0-55	0-56	0-57	0-58	0-59	0-60
1	V ws 21												
2	V TOTAL												
3	VI ew 21	3,421	661		219			5,097	129			1,332	1,002
4	VI ew 23												
5	VI ew 26	30	55			252		503					
6	VI ew 28												
7	VI es 19	2,023	427	135	355	25	727	3,697	541	401	333	1,082	5,152
8	VI es 20	162				7,391		207					
9	VI es 22												
10	VI es 23												
11	VI es 24	630	1,679				4,103	198	2,329	5,919	12,824		
12	VI es 25	605	485				335	3			1	1	
13	VI es 27												
14	VI ws 19	60					175	42	500	175	185	479	82
15	VI so 01	20											
16	VI so 10							30					
17	VI so 12												
18	VI so 14	345	560				9,667	4,049	1,638	665	1,075		
19	VI so 16								167	50	250		
20	VI so 18	646	20	742		1,130		2,985	90			1,855	3,214
21	VI so 19	62											
22	VI so 21	30					1,633	1,397					
23	VI se 13												
24	VI se 15	1,310	1,965				3,233	465	908	1,075	1,461		
25	VI se 17	1,101		775	215			16,080	40			3,272	4,324
26	VI se 21												
27	VI TOTAL	10,445	5,852	1,652	789	8,798	19,873	34,753	6,342	8,285	16,129	8,021	13,774
28	VII ew 30	64						1,577	820			878	90
29	VII ew 32												
30	VII es 29	1,832					335	214	538		15		
31	VII es 30												
32	VII es 34												
33	VII es 35						77		1,962	2,693	4,161		
34	VII es 36	18,407	5.156	252	95	388	1,947	992	5,092	4,764	6,902	2,691	3,333
35	VII ws 20								142	40			
36	VII TOTAL	20,303	5,156	252	95	388	2,359	2,783	8,554	7,497	11,078	3,569	3,423
37	VIII ew 39			5		40		110			25	25	22
38	VIII es 37												
39	VIII es 38												
40	VIII ws 00							20	505	27	10	20	
41	VIII ws 23	50				19		238	140		105	40	305
42	VIII ws 24						27	465	76	8		102	182
43	VIII so 00	5	60			2	98	46	13		40	1	50
44	VIII TOTAL	55	60	5		61	125	879	734	35	180	188	559
45	V-VIII TOTAL	30,803	11,068	1,909	884	9,247	22,357	38,415	15,630	15,817	27,387	11,778	17,756
46	II-VIII TOT.	54,301	21,902	5,032	4,217	13,597	38,501	102,601	24,424	16,743	28,788	28,299	32,839

TABLE 7-57. Land capability units in West Sound Basins (acres)[1] (continued)

Sheet 4 of 4

WATERSHEDS													Line
0-62	0-63	0-66	0-67	0-68	0-69	0-70	0-71	0-72	0-73	0-75	0-76	Total	
	11		5					122				138	1
	11		5					122				138	2
4,037	773		7	2,793	11,486	9,940	3,191	9,922	3,811	158		57,979	3
								1,884	183	422	223	2,712	4
1,517							108	7,093	1,198			10,756	5
51												51	6
6,923	87		2,928	7,574	4,871	4,199	450	2,636	741			45,307	7
30							298	7,282				15,370	8
								1,626	45	5		1,676	9
								270	148			418	10
		1,260	6,235				2,874	1,137	32			39,220	11
						1,349						2,779	12
			319				2,732	4,688	1,034	200		8,973	13
				234								1,932	14
												20	15
												30	16
								2,999	1,252			4,251	17
		340	506				732	263				19,840	18
												467	19
15,305	145			1,971	10,468	23,161	20	2,739	384	140	40	65,055	20
												62	21
								675	223			3,958	22
								4,248	186	25		4,459	23
		45	49									10,511	24
14,498	465			9,299	8,737	9,573						68,379	25
								23				23	26
42,361	1,470	1,645	10,044	21,871	35,562	48,222	10,405	47,485	9,237	950	263	364,228	27
			3,458	1,824			1,637	4,115	936	6		15,405	28
								158	39	354	3,006	3,557	29
30		10	313				201	526				4,014	30
							20	1,625	289			1,934	31
								415				415	32
		1,433	1,723				1,933	3,020		191		17,193	33
3,690	5,017	5,382	2,221	5,135	5,123	3,125	1,118	680		2,969	4,097	88,576	34
												182	35
3,720	5,017	6,825	7,715	6,959	5,123	3,125	4,909	10,539	1,264	3,520	7,103	131,276	36
145	143		22	26	85	861	142	1,335	29	67	75	3,157	37
							707	1,168				1,875	38
								156				156	39
			71	9			20					682	40
38		69	61	15	25	256	145	1,074		19	75	2,674	41
102	25			260	420	868	22	20		8	42	2,627	42
							11	474	9			809	43
285	168	69	154	310	530	1,985	1,047	4,227	38	94	192	11,980	44
46,366	6,666	8,539	17,918	29,140	41,215	53,332	16,361	62,373	10,539	4,564	7,558	507,622	45
79,820	23,098	8,694	18,870	53,841	76,338	95,120	23,023	113,262	22,326	14,572	15,307	915,515	46

1/ Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include lands within national forest or park boundaries.

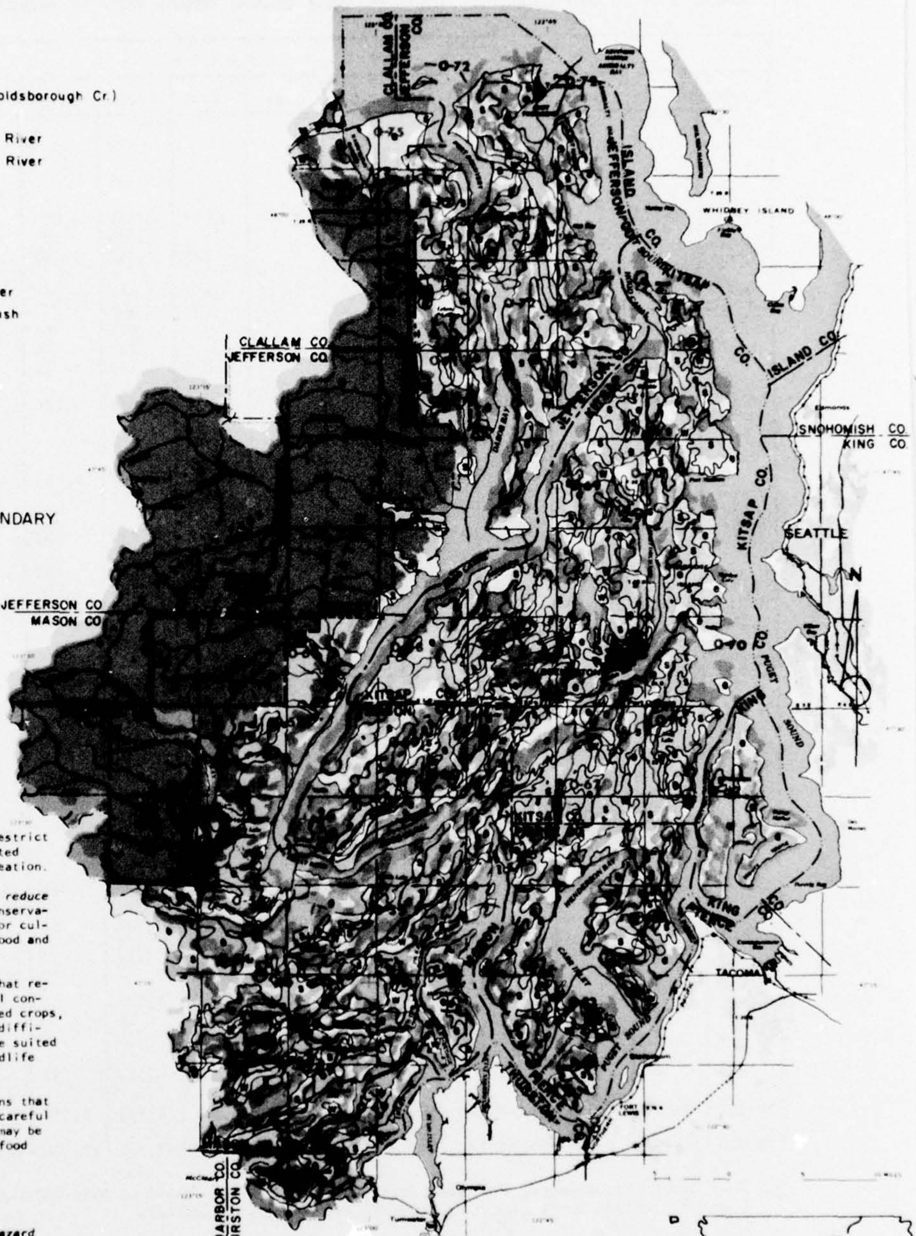
2/ See Exhibit 1 for description of capability units.

LEGEND

Wash-NP-Pacific-O

- 0-49 Skookum Creek
- 0-50 Isabella Lake
- 0-51 Anderson Island
- 0-52 McNeil Island
- 0-53 Harstene Island
- 0-54 West of Shelton (Goldsborough Cr.)
- 0-55 N. W. Shelton
- 0-56 S. Fork Skokomish River
- 0-57 N. Fork Skokomish River
- 0-58 W. Hood Canal
- 0-59 Tahuya River
- 0-60 N. Hood Canal
- 0-62 Carr Inlet Area
- 0-63 Vashon Island
- 0-66 Hamma Hamma River
- 0-67 Dosewallips-Duckabush
- 0-68 E. Hood Canal
- 0-69 West Kitsap Area
- 0-70 East Kitsap Area
- 0-71 Quilcene
- 0-72 East Jefferson
- 0-73 Chimacum Creek
- 0-75 Sequim Bay Area
- 0-78 Johnson Creek

WATERSHED BOUNDARY



LEGEND

LAND SUITED FOR CULTIVATION AND OTHER USES

I — *Soils in Class I have few limitations that restrict their use.* They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II — Soils in Class II have some *limitations that reduce* the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III — Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

IV — Soils in Class IV have very severe limitations that *restrict* the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

V — Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

VI — Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

VII — Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

VIII — *Soils and land forms in Class VIII have limitations* that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

FIGURE 7-42

WEST SOUND BASINS
GENERALIZED LAND CAPABILITY MAP

LOCATION MAP

TABLE 7-58. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	43,107[2]	43,107[2]	43,107
Watershed protection & rehabilitation[3]	acre	48,244	46,690	45,137
Drainage improvement	acre	17,138	28,563	38,084
Irrigation development[4]	acre	5,000	7,000	15,000
Water for irrigation[5]	ac.ft.	12,750	17,850	38,250

[1] A total of 70,968 acres in the West Sound Basins are subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated here.

[2] Includes 1,554 acres expected to be lost to other uses by 2000 and 3,107 acres by 2020.

[3] Includes 5,137 acres of rangeland.

[4] According to Appendix VII, Irrigation, there were 1,200 acres (using 3,060 acre-feet of water) irrigated in 1966. Irrigation Appendix projections show 1,600 acres irrigated by 1980, 2,100 acres by 2000, and 2,600 acres by 2020.

[5] Based on gross diversion requirements of 2.55 acre-feet per acre, estimated by Irrigation Committee in Appendix VII, Irrigation.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the West Sound Basins is summarized under the topic "Program Implementation" immediately following Forestry. A more complete description is found in Appendix XIV, Watershed Management, West Sound Basins section.

FORESTS

PRESENT STATUS

The West Sound Basins have a prominent place in the resource analysis of the Puget Sound Area. It is first in commercial forest area, second in total hydrologic area. Over 1,137,000* acres, or 88% of the Basins, are classified as forest land (Table 7-59). Continuous large forest areas are found throughout the western two-thirds of the Basins with many smaller forest areas scattered over the eastern third. Eight percent of the total forest land, or 94,430 acres, is held in a reserved status, primarily in the Olympic National Park. The remaining available forest land is classified by resource zones in the following tabulation.

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	508,140	49
Principal Forest	494,150	47
Upper Forest	13,450	1
Subalpine	27,130	3
Total available	1,042,870	100

The West Sound Basins contain 994,010 acres of commercial forest land capable of producing continuous crops of industrial wood. These lands support a 12.2 billion board foot sawtimber inventory measured by the International ¼-inch Rule

*Does not include nonforested lands commonly associated with forest areas.

TABLE 7-59. West Sound Basins—Area of forest land, in acres, by ownership and type

Cover Type or Land Class	Available								Total Available & Unavailable
	National Forest	Other Federal	State & County	Muni-cipal	Indian	Private	Total Available	Unavail-able	
Douglas fir									
seedlings & saplings	16,800	2,660	32,040	2,450	1,010	103,470	158,430	190	158,620
poletimber	23,720	2,700	29,990	4,420	3,190	227,710	291,730	2,580	294,310
small young growth saw	41,050	2,600	23,670	1,100	1,040	170,350	239,810	5,640	245,450
old growth and large young growth sawtimber	47,700	150	5,530	210	150	25,670	79,410	20,480	99,890
True fir—mountain hemlock									
seedlings & saplings	--	--	--	--	--	1,170	1,170	--	1,170
poletimber	170	--	--	--	--	--	170	--	170
small sawtimber	--	--	--	--	--	1,170	1,170	1,010	2,180
large sawtimber	10,650	--	--	--	--	--	10,650	12,560	23,210
Western hemlock									
seedlings & saplings	400	--	50	--	--	40	490	--	490
poletimber	1,130	--	270	--	--	12,060	13,460	50	13,510
small sawtimber	540	--	1,330	140	--	7,350	9,360	1,460	10,820
large sawtimber	29,570	10	20	--	--	1,730	31,330	10,770	42,100
Western redcedar									
poletimber	100	--	--	--	130	3,820	4,050	--	4,050
small sawtimber	--	--	--	--	--	4,850	4,850	10	4,860
large sawtimber	530	--	--	--	--	2,510	3,040	230	3,270
Lodgepole pine									
seedlings & saplings	--	--	2,620	--	60	5,130	7,810	220	8,030
poletimber	--	--	360	--	--	2,590	2,950	--	2,950
Sitka—Englemann spruce									
poletimber	--	--	--	--	--	130	130	--	130
large sawtimber	--	--	--	--	--	160	160	--	160
Western white pine									
seedlings & saplings	--	--	--	--	--	300	300	--	300
poletimber	--	--	100	--	--	70	170	--	170
small sawtimber	50	--	--	--	--	--	50	--	50
Ponderosa pine									
seedlings & saplings	--	--	230	--	--	--	230	--	230
SUBTOTAL, softwood	172,410	8,120	96,210	8,320	5,580	570,280	860,920	55,200	916,120
Hardwood									
seedlings & saplings	--	--	--	--	--	4,590	4,590	10	4,600
poletimber	320	890	720	240	420	44,200	46,790	90	46,880
small sawtimber	230	--	9,540	--	1,200	61,070	72,040	320	72,360
large sawtimber	40	--	--	--	170	200	410	40	450
SUBTOTAL, hardwoods	590	890	10,260	240	1,790	110,060	123,830	460	124,290
Nonstocked									
cutover	1,290	10	2,570	390	--	4,670	8,930	60	8,990
deforested by fire	330	--	--	--	--	--	330	180	510
SUBTOTAL, nonstocked	1,620	10	2,570	390	--	4,670	9,260	240	9,500

(table continued on following page)

TABLE 7-59. West Sound Basins—Area of forest land, in acres, by ownership and type (continued)

Cover Type or Land Class	Available								Total
	National Forest	Other Federal	State & County	Muni-cipal	Indian	Private	Total Available	Unavail-able	Available & Unavailable
TOTAL, productive land	174,620	9,020	109.040	8,950	7,370	685,010	994,010	55,900	1,049,910
Subalpine	27,130	--	--	--	--	--	27,130	35,440	62,570
Noncommercial, rocky	20,600	--	70	--	--	1,060	21,730	3,090	24,820
TOTAL, unproductive land	47,730	--	70	--	--	1,060	48,860	38,530	87,390
TOTAL, all forested land	222,350	9,020	109,110	8,950	7,370	686,070	1,042,870	94,430	1,137,300

(Table 7-60). The Basins contain 20% of Puget Sound Area's commercial forest and 12% of its sawtimber inventory. The proportion of volume to acres is lower than other basins due to the prevalence of relatively dry sites within the "rain shadow" of the Olympic Mountains. Privately-owned forest lands, make up 69% of the commercial forest area. Large corporate ownerships control 165,670 acres and medium sized ownerships 11,460 acres. The West Sound Basins contain the greatest area of small-sized private holdings in the Puget Sound Area. Owners of farms and ranches, along with investment ownerships, control 507,880 acres. Many of these owners carry on tree farm practices, particularly Christmas tree culture. Public-ownerships, control 309,000 acres of commercial forest land. Ownership is 57% National Forest, 35% State and County, 3% other Federal, 3% municipal, and 2% Indian land.

A well-established forest products industry is located in the Basins with the larger plants concentrated at Shelton and Port Townsend. Of 34 wood products plants, 10 are found at Shelton, 5 at Port Townsend, 2 each at Bremerton, Port Gamble, Port Orchard, and Poulsbo, and one each at Tahuya, Union, Brinnon, Gardiner, Port Ludlow, Quilcene, Gorst, Silverdale, Windslow, Suquamish, and Vashon. All of these plants are rated as sawmills except for the paper mill in Port Townsend. Additional items produced as a part of the sawmill operation are furniture, hardboard, chips, shakes, shingles, plywood, and other special products. Total raw material needs average one million board feet daily.

Problems related to forest land management and industrial operations are similar to those discussed for other Basins. Intermingled Federal, State, and private lands cause managers to coordinate long-range plans for access roads and timber harvest programs so that expenditures for capital improvements will not be duplicated. The northwestern portion of the Basins contain large areas of unstable clay soils that require extensive drainage work during road construction and in other land use development. Fortunately all ownerships are under professional supervision so that the latest and best techniques are being applied to the soil problems. The forest products industry has the usual problems of acquiring sufficient raw material for manufacture during periods of fluctuating markets.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

No determination of the demand for wood products is made specifically for the West Sound Basins. The nature of the forest products industries, particularly the relative ease of log transportation between the Basins, would make such a determination rather meaningless. In addition, a specific figure would imply that a production goal was established for the Basins, which is not the case. Production goals are established for the Puget Sound Area as a whole, with the assumption that considerable shifts in production between the Basins will occur, depending upon the actual pattern of industrial and land use development.

For sake of basin comparison, however, there is some value in showing the percentage of demand that may be supplied by the West Sound Basins in the future. In 2020, the Basins are expected to contain about 20% of the commercial forest land in the Puget Sound Area. The percentage in earlier periods is slightly lower. It is, therefore, assumed that the

TABLE 7-60. West Sound Basins—Volume of sawtimber and growing stock, by ownership, on productive forest land

Species or Group	National Forest	Other Federal	State & County	Municipal	Indian	Private	Total Available	Unavailable	Total Available & Unavailable
	Available								
Sawtimber–Thousand board feet, International ¼-inch Rule									
Douglas-fir									
small sawtimber	642,720	42,150	405,480	24,760	17,350	2,735,540	3,868,000	85,060	3,953,060
large sawtimber	2,647,930	12,590	346,950	19,250	11,240	1,678,640	4,716,600	1,128,930	5,845,530
True fir–mountain hemlock									
small sawtimber	280	--	--	--	--	19,640	19,920	18,180	38,100
large sawtimber	654,950	--	--	--	--	650	655,600	711,700	1,367,300
Western hemlock									
small sawtimber	10,030	--	17,190	2,330	--	122,780	152,330	26,080	178,410
large sawtimber	1,551,310	490	1,410	--	--	103,780	1,656,990	610,350	2,267,340
Western redcedar									
small sawtimber	110	--		--	210	81,330	81,650	220	81,870
large sawtimber	47,550	--		--	220	158,590	206,360	13,020	219,380
Other softwood species									
small sawtimber	900	--	1,790	--	30	7,230	9,950	110	10,060
large sawtimber	--	--	1,790	--	30	16,650	18,470	110	18,580
SUBTOTAL, softwoods	5,555,780	55,230	774,610	46,340	29,080	4,924,830	11,385,870	2,593,760	13,979,630
Hardwoods									
small sawtimber	2,740	680	97,820	180	12,670	638,380	752,470	3,620	756,090
large sawtimber	2,060	680	730	190	8,150	48,970	60,780	1,780	62,560
SUBTOTAL, hardwoods	4,800	1,360	98,550	370	20,820	687,350	813,250	5,400	818,650
TOTAL SAWTIMBER, all species	5,560,580	56,590	873,160	46,710	49,900	5,612,180	12,199,120	2,599,160	14,798,280
Growing Stock–Million cubic feet									
Douglas-fir	599.4	10.0	137.1	8.0	5.2	804.1	1,563.8	221.1	1,784.9
True fir–mountain hemlock	118.5	--	--	--	--	3.7	122.2	132.0	254.2
Western hemlock	304.2	0.1	3.6	0.5	--	44.1	352.5	124.0	476.5
Other softwood species	19.2	--	1.4	--	0.2	104.4	125.2	5.3	130.5
SUBTOTAL, softwoods	1,041.3	10.1	142.1	8.5	5.4	956.3	2,163.7	482.4	2,646.1
Hardwoods	1.9	0.5	39.0	0.1	8.2	271.7	321.4	2.1	323.5
TOTAL GROWING STOCK, all species	1,043.2	10.6	181.1	8.6	13.6	1,228.0	2,485.1	484.5	2,969.6

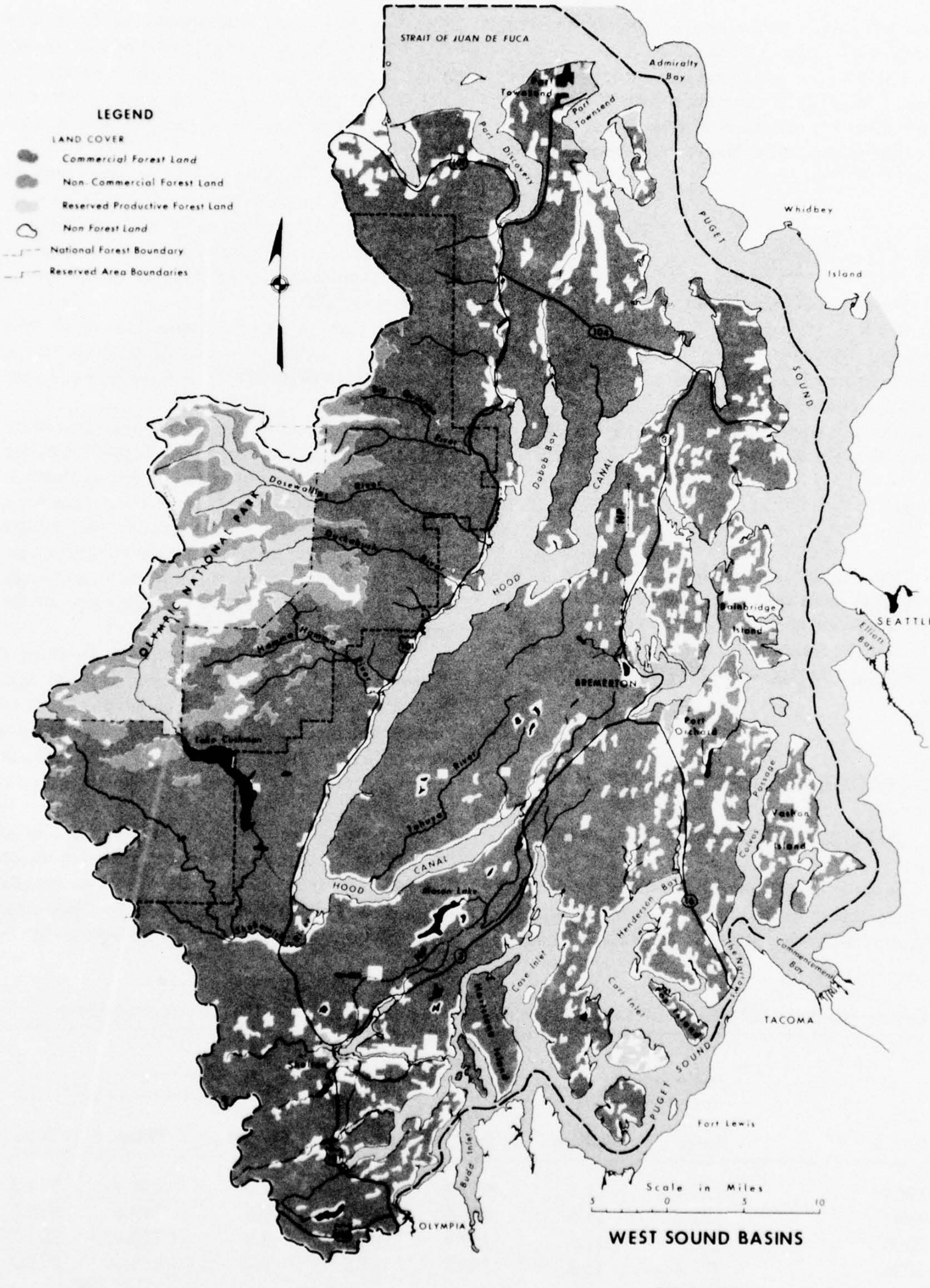


FIGURE 7-43. Forest lands in the West Sound Basins

FORESTS

Basins will supply approximately 20% of the total wood products demand in the future.

The effect of competing uses for forest lands is discussed in detail in the section covering the Puget Sound Area. The estimated diversion of forest land from these causes in the West Sound Basins is shown below:

Type of Land Diversion	Acres Diverted (2020)
Parks, Wilderness, Campgrounds, or other Recreation Use	5,290
Roads and Highways	34,300
Urban-Industrial Development	37,600
Reservoirs, Powerlines, and other miscellaneous conversion	1,000
Private Land Use Reservations	95,000
Total	173,190

The current and prospective changes in the commercial forest land base from all causes are given in the tabulation at the bottom of this page.

Specific measures for soil and water protection are discussed in Appendix XIV, Watershed Management.

PROGRAM IMPLEMENTATION

AGRICULTURE AND FORESTS

In order to sufficiently provide for the needs of the West Sound Basins, as set forth in the previous pages, the following plan has resulted. It is multipurpose in nature and will provide for floodwater damage prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development. Other measures provide for water quality and quantity control, recreation, and fish and wildlife development.

This plan includes programs and projects designed to accomplish specific objectives of conservation and development, and provides for the full development of lands expected to remain in cropland by 2020. Approximately 6,000 acres will be lost to other uses by 2020.

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000); and (c) distant future (2000-2020).

Program measures are on-site practices which take advantage of developments made possible by the structural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management, and irrigation development. Total cost of the program for the early action period is $49,538,000.

There are two early action projects described in Appendix XIV, Watershed Management. Primary agricultural benefits from these projects are prevention of flooding and drainage improvement. The two projects are expected to cost $59,215 annually, and to result in annual benefits of $149,925 for a benefit cost ratio of 2.5 to 1.

Twelve projects with an installation cost of $8,055,000 are proposed for the period between 1980 and 2000, and seven projects with an installation cost of $970,000 are planned for the 2000-2020 time period. Program costs are expected to be

Current and projected commercial forest area in the West Sound Basins 1965-2020 (in thousand acres)

	Ownership						
	Private			Public			
Period	Large	Medium	Small	NF	Other Federal	Other	Total
1965	165.7	11.5	507.9	174.6	9.0	125.3	994.0
1980	181.8	11.5	458.6	170.6	9.0	123.6	955.1
2000	216.3	11.3	369.9	166.2	8.9	121.7	894.3
2020	231.6	11.1	288.5	161.5	8.7	119.6	821.0

$71,602,000 for the 1980-2000 period and $74,983,000 for the 2000-2020 time period. Total cost of the plan is expected to be $206,227,000.

A summary of the early action projects is given in Table 2-21 of the Puget Sound Area section on agriculture. A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, Watershed Management, West Sound Basins section.

MINERALS

Current (1966) mineral production from the West Sound Basins is confined entirely to nonmetallic products—sand and gravel, stone, and peat. Clay, manganese, copper, and iron have been produced from the area, the last two in only minor quantities. One limestone deposit occurs, but no stone has been produced from it. Diatomite also occurs in the area.

The locations of the known mineral deposits in the Basins are shown on Figure 7-44. The open circles on the maps indicate properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

Stone Other Than Limestone

Stone has been produced from seven basalt quarries, two granite quarries, and one sandstone quarry. Currently (1966), only two quarries, both in basalt, are being operated. At the Mats Mats Bay quarry, basalt is quarried at sea level and loaded directly onto barges for transportation to various destinations around the Sound.

Stone production statistics are not available for publication. Reserves are adequate for many years at the present production rate.

Sand and Gravel

Glacial debris that at many places contains material suitable for aggregate covers most of the lowland part of the Basin (Figure 7-44). Reported gravel pits number 125; however, there are probably more. Sixty-eight of these pits have produced in the past 20 years.

Production statistics are not available for publication. Sand and gravel reserves in the area appear to be adequate for many years.

Peat

Forty-six peat bogs covering 5,763 acres have been investigated. Twenty-five of these bogs contain sphagnum moss. The largest bog investigated covers 2,065 acres and is in Jefferson County.

Four peat producers are currently operating. No estimate of production is available for publication. Reserves are very large.

Clay

Clay was formerly produced from three pits, and the material from the deposits was used to make common brick. No estimate of production is available for publication.

Iron

The West Sound River Basins had the distinction of producing the first pig iron in Washington. A blast furnace began operation at Irondale on Port Townsend Bay in 1880. Ore for the furnace was dug from the Chimacum limonite bog. The bog ore did not prove satisfactory, and the furnace was shut down in 1891. Later, it was rebuilt and ore from outside the Basins was used.

No production figures are available for the Chimacum iron (Figure 7-44, No. 92), and the amount of bog iron left in the deposit is unknown. The exact location of the bog from which the Chimacum iron was produced is unknown, but the approximate location is shown on Figure 7-44.

Copper

Two copper properties are known, the Black Tail and the Black and White (Figure 7-44, No. 93). A test shipment of 5 tons was made from the Black and White prospect in 1915, but no other shipment has since been reported. The mineralized zone consists of three irregular lenses along an altered basalt-phyllite contact. The Black Tail produced copper, but there is no record of the amount.

MINERAL PROPERTIES IN WEST SOUND BASINS*

Explanation for Figure 7-44

Metallic Minerals
(with production or reserves data where available)

Copper (2 properties)
- 93 – Black and White (prod.–5 tons)

Iron (1 property)
- 92 – Chimacum

Manganese (21 properties)
- 94 – Black Hump
- 95 – McKean
- 96 – Triple Trip (prod.–1 carload)

Nonmetallic Minerals
(with reserves data where availabe)

Common clay (3 properties)
- 83 – Fox Island
- 81 – Harper
- 82 – Port Orchard

Diatomite (3 properties)

Stone Deposits

Basalt (7 properties)

Granite (2 properties)

Limestone

Reserves
Less than 10,000 tons (1 property)

Sandstone (1 property)

*Some properties not plotted on map because of poor description of location and/or lack of space.

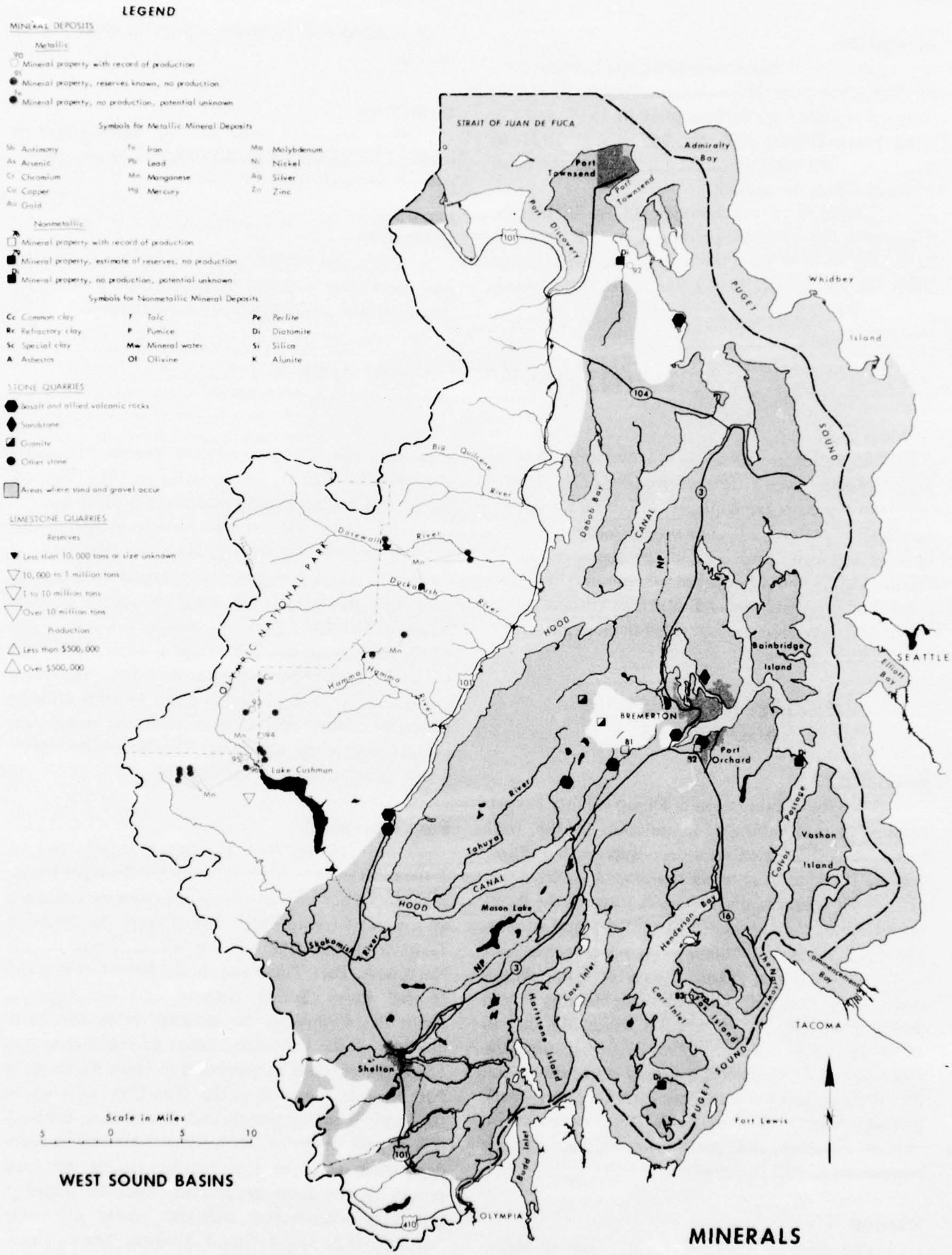


FIGURE 7-44. Mineral resources in the West Sound Basins

Manganese

Three of 21 manganese prospects have a record of production. The McKean claim (Figure 7-44, No. 95) had reported production prior to 1918, and the Black Hump (Figure 7-44, No. 94) prior to 1924. In both cases, the amount of production and character of the ore body are unknown.

A carload of ore assaying 35 to 45 percent manganese and 17 to 30 percent silica is reported to have been shipped from the Triple Trip mine (Figure 7-44, No. 96) during World War I. The ore minerals were concentrated in lenses along a basalt-limestone contact.

Limestone

One limestone body has been investigated. It contains an estimated 50,000 tons of limestone but has had no production.

Diatomite

Three diatomite deposits are known in the area, but none have a record of production. Preliminary investigations indicate they are subcommercial.

INTENSIVE LAND USE

The Basins are relatively undeveloped, excepting cities and towns at favored locations. The Basins have seven incorporated places, one built-up island, and approximately 27 unincorporated places. The bulk of intensive land uses in the Basins is to be found within the boundaries of the incorporated places and on Vashon Island. Much of the remainder of the intensive land use is located in close proximity to the cities and towns.

INCORPORATED CITIES AND TOWNS

Bremerton

The city of Bremerton in Kitsap County has the heaviest concentration of population in the West Sound Basins. Located on a deep-water arm of Puget Sound, 15 miles west of Seattle, and 33 miles north of Tacoma, Bremerton's primary industry is the Puget Sound Naval Yard, established in 1891 and responsible for repairing and building U.S. naval vessels. As a result of the Naval Yard, Bremerton's population more than doubled with the shipbuilding boom during World War II. Population within the city in 1940 was 15,134 and in 1950, 27,678. During the 1950-60 decade, the increase slowed considerably and the 1960 population was only 28,922. Since 1960, however, steady natural growth, increases relative to military activities, and Seattle spillover, has raised the population to 36,170 (1967).

Shelton

The city of Shelton, county seat of Mason County, is on the southern end of Puget Sound approximately 50 miles west of Tacoma, 82 miles southwest of Seattle. Incorporated in 1889, Shelton has always been a logging and sawmill town with its economy dependent on the lumber industry. The primary employer in the city is the Simpson Lumber Company, which is engaged in sustained yield logging and in developing new wood products through research. The 1967 Shelton population was 6,250; in 1940, population was 3,707; and in 1950, 5,045; but in 1970 projection estimate is 7,500, the main increase factor being highway improvements creating closer proximity and ease of travel to population centers and recreation areas. The Washington State Corrections Center is located nearby.

Port Townsend

The city of Port Townsend, county seat of Jefferson County, is situated on the Quimper Peninsula off the northeastern tip of the Olympic Peninsula at the entrance to Puget Sound from the Strait of Juan de Fuca. One of the oldest cities of the Northwest, Port Townsend, is the historical gateway to the Puget Sound country and the Olympic Peninsula. Following its designation as the headquarters of the Customs District of Puget Sound in 1854, the city was incorporated in 1860. No longer is Port Townsend known as the "Key City" as it was in the days of sailing vessels and steamboats; although still a port of entry, its present economy is more dependent on paper mill, lumber, fishing, sea food products, and local agriculture, than on shipping. Currently deactivated military posts, a marine hospital, U.S. Coast Guard Training Station, and, since 1927, the Crown Zellerbach Corporation craft

mill have been the mainstays of the economy.

According to Hazel Mills, Washington State Librarian, "a railroad building and land boom began in the 1880's with the hope that the city would become a main line terminal, and enough three and four-story substantial brick buildings were erected along the main street to serve a city of 20,000. The main line railroad failed to materialize and the panic of the early 1890's, with the collapse of the land boom, reduced the population from 7,000 to less than 2,000. Today, the picturesque Victorian business buildings and residences make Port Townsend one of the most historic and interesting cities in the State. But it is also a modern city with fine schools and recreational facilities."

The 1950 population of Port Townsend was 6,888 but decreased 26.3 percent to 5,074 in 1960. Since then, there has been a slow upward trend to a 1967 population of 5,430.

Port Orchard

The city of Port Orchard, county seat of Kitsap County, is situated on the south shore of Sinclair Inlet across from Bremerton, approximately 20 miles west of Seattle and 33 miles north of Tacoma. Under its original name of Sidney, the town was platted in 1854 and incorporated in 1893, a year after being designated county seat. The name was changed to Port Orchard in 1895 and in those early days, lumber and wood products were the main industries.

Today many Port Orchard residents work in the Puget Sound Naval Yard across the Bay. Other current employment is related to the large forest products packing plant and the town's being a trading and marketing center for outlying farms. The city has grown from a population of 1,566 in 1940 to a 1960 population of 2,778. In 1967, the 3,850 population was somewhat below earlier predictions for that year.

Poulsbo

The city of Poulsbo, in Kitsap County, at the head of Liberty Bay, is on an arm of Puget Sound and was settled in 1883 as a Norwegian fishing village. Incorporated in 1907, Poulsbo is still predominantly a fishing-oriented town, although oyster raising, logging, farming, boat building and employment at Bremerton Navy Yard provide other sources of income. Population increase from 1940-50 was approximately 50 percent, and in 1967, population was reported as 1,732.

Gig Harbor

The city of Gig Harbor is largely a fishing and shipbuilding town with a 1967 population of 1,435. Originally platted as a logging town with a sawmill, by the time of incorporation in 1946, Gig Harbor's location, on Kitsap Peninsula, and her potential as a lake-like haven for ships was well recognized. A fishing fleet now operates from the harbor.

Winslow

The city of Winslow was incorporated in 1947 and had a 1967 population of 1,270.

Vashon Island

Vashon Island, centrally located in the Puget Sound Area, is 45 minutes to the center of Seattle by ferry and 30 minutes to Tacoma by ferry. The unincorporated island is administered by King County and had a 1965 population of approximately 5,600, a 2,500 increase over 1940.

Unincorporated townships include places in Jefferson County: Hadlock, Chimacum, Center, Port Ludlow, Leland, Shine, Dabob, South Point, and Quilcene.

Places in Kitsap County include: Hansville, Port Gamble, Bangor, Keyport, Chico, Seabeck, Silverdale, Kingston and Suquamish.

Others are Longbranch and Vaughn in Pierce County and Allyn in Mason County.

TRANSPORTATION

Rail—The area is poorly served by railroad facilities, as there are no through lines. A railroad ferry which serves the northern part of the Basins is operated from Seattle to Port Townsend. In the southern part of the Basins, the railroad serves only the area from Bremerton to Shelton, and for freight only.

Highways—U.S. Highway 101 serves the Basins from north to south, and an adequate system of State and county roads serves the developed areas.

Navigation—Bremerton and Port Townsend are deep water ports, and there are large numbers of moorage facilities for pleasure craft, both on Puget Sound and the Hood Canal arm of Puget Sound.

Airways—Numerous small airfields are in the Basin for civilian and emergency use.

LAND USE CHARACTERISTICS

There are 1,281,387 acres of land within West Sound Basins and 12,606 acres of inland water. Table 7-55 contains the figures showing the various amounts of major land use acreages within the Basins.

Figure 7-41 portrays the present land use for the West Sound Basins. It is evident from this map, that only a small amount of land is now being put to intensive use in the West Sound Basins.

Intensive Land Use

At the present time (1967) intensive land uses occupy some 42,161 acres or 3.3 percent of the Basins' land area. Nearly all of the intensive land use areas are located within or near the Basins' incorporated and unincorporated communities although a few intensive uses will be found at scattered locations throughout the Basins. The following list contains the land use figures for the intensive land use subgroups.

Railroads	Roadways	Airports	Urban (Built-up)	Total
998	10,343	2,123	28,697	42,161

Rural Nonagricultural

Since many of the land uses classified within the rural nonagricultural category are similar in character and often associated with or are the forerunners of intensive land use, they have been included in this portion of the Appendix for the convenience of the reader. The following list contains the acreages of the several subgroups in the rural nonagricultural category.

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm yards)	Total
56,147	2,492	338	5,231	64,208

Land Ownership

Of the total land area (1,281,387 acres) in the West Sound Basins, 38.3 percent is in private ownership; 19.9 percent in private corporate ownership; 30.3 percent in Federal ownership; 8.8 percent in State ownership; and 2.7 percent in local government ownership. The bulk of the private corporate, Federal and State ownerships are forested areas. Land areas owned by local governments (city, county and special districts) consist mainly of streets, facilities, local parks and similar areas. Other private ownerships consist mainly of intensive, rural nonagricultural land areas.

TRENDS AND POTENTIALS

Intensive land use in the West Sound Basins amounts to some 42,161 acres or slightly less than two (2) townships of land. This area accounts for approximately 3 percent of the total area of the Basins. Intensive land use requirements are presently being filled in and around the various communities of the Basins, principally Bremerton, Port Townsend, Shelton and Port Orchard. Other intensive land uses are found in suburban and scattered developments occurring on Bainbridge and Vashon Islands and at various locations on the shores of Puget Sound. Within the West Sound Basins there are approximately eleven (11) townships comprising some 253,000 acres which are considered most likely to receive pressure for intensive use purposes. Due to limitations of geography and topography, only a certain portion of this area will have a high potential for future intensive development. The potential growth area is located in the Kitsap County portion of the Basins, along the shores and on the islands of Puget Sound and the Gig Harbor Peninsula in Pierce County. In addition, there is a small potential area located in Mason County around and to the south of the city of Shelton. It should be noted that any future construction of a cross-Sound bridge connecting the Seattle area with Bainbridge Island and the mainland, will greatly increase growth and development prospects within the Basins. This will be examined in greater detail in the chapter on Future Land Use, and will be one of the alternative development patterns for West Sound Basins.

PRESENT AND FUTURE NEEDS

Growth within the West Sound Basins has been slow in past years, with slightly more than 3 percent of the land area now being occupied by intensive land use. Present trends show that intensive land use of the Basins will continue to fill in and around the various communities of the Basins, principally Bremerton, Port Townsend, Shelton, and Port Orchard. Other scattered developments that now exist and will continue to grow are on Bainbridge and Vashon

Islands, and at various locations along the shore of Puget Sound. This growth pattern will continue through the projection period, but will be accelerated at the latter portion. It should be noted that if a cross-Sound bridge is constructed connecting the Seattle metropolitan area with the Peninsula mainland, there will be a need to reassess population and intensive land use projections. It is felt that a cross-Sound bridge would primarily serve to eventually make the Peninsula area a suburb to the greater Seattle metropolitan area.

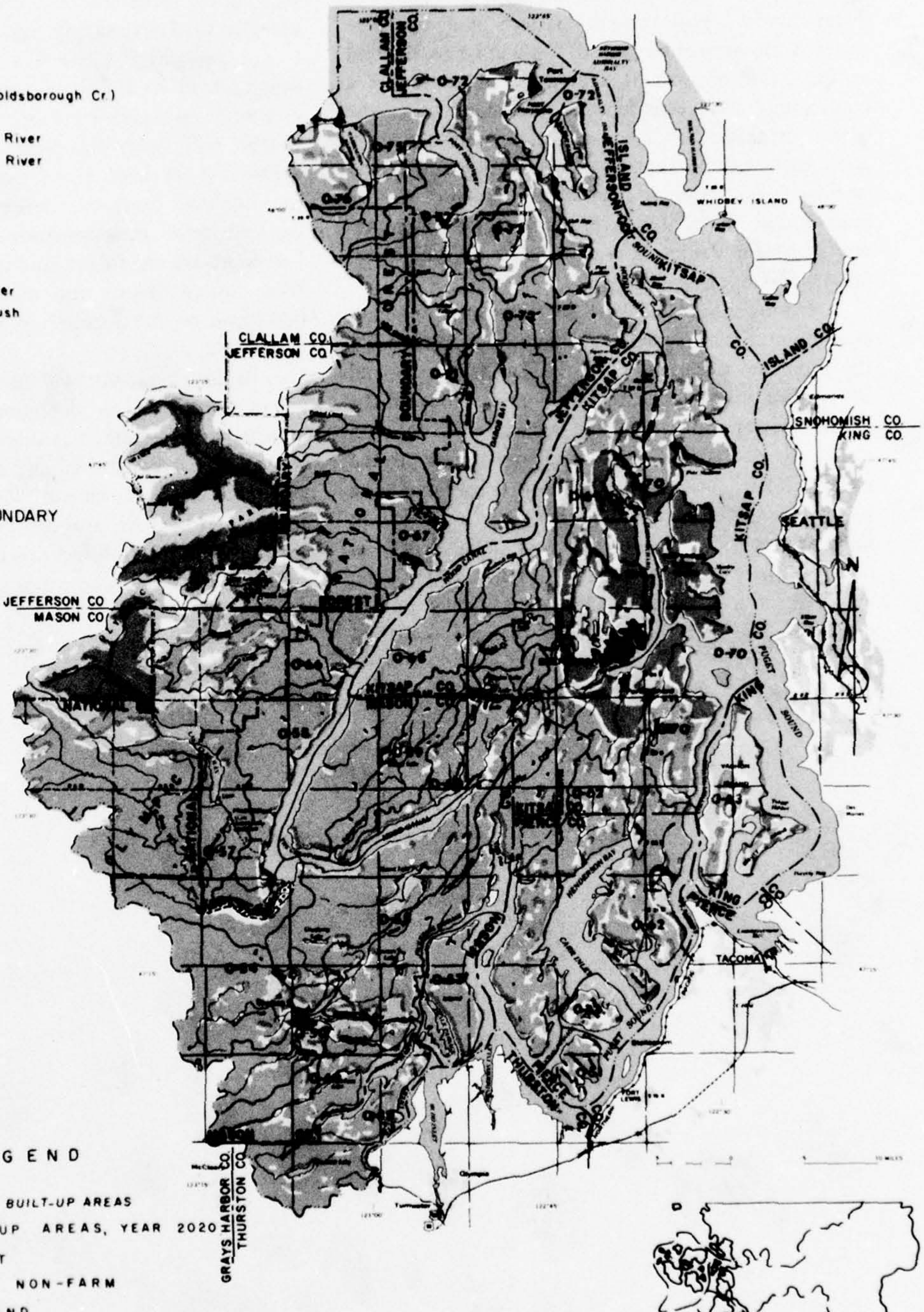
Future needs for land for intensive uses have been determined by two major factors; the first being the projected population for the Basins, the second being density at which this population settles on the land. Present population in the Basins is 134,200 with a density pattern of 2.9 persons per acre in the intensive land use areas. Without the cross-Sound bridge the population in the Basins is projected to increase to 432,700 by the year 2020, with an intensive land use density of 6 persons per acre, resulting in a total of 71,000 acres being put to intensive uses. With 235,000 acres deemed likely and suitable for future conversions and only 71,000 acres actually needed to satisfy the intensive land use needs to the year 2020, there is a definite need to guide development to those lands which are best suited for intensive uses and to those areas where land use change will cause the least conflict between uses competing for land. If a cross-Sound bridge is built, the intensive land use needs will require 100,300 acres to satisfy the population influx by 2020. Figure 7-45 portrays the future land use pattern (C_2) for the West Sound Basins for the year 2020 and was developed on the assumption a bridge would be built after 1980.

Industry growth will be in the pulp and paper manufacturing and in recreation. The pulp and paper industry will require that there be a maintenance of enough forest land to supply a major portion of its raw materials requirements. Recreation demand will continue to grow through the planning period, requiring both public and private investments in land and development to be made if the demand is to be satisfied.

LEGEND

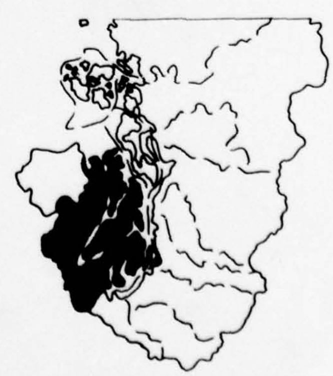
Wash-NP-Pacific-O

- 0-49 Skookum Creek
- 0-50 Isabella Lake
- 0-51 Anderson Island
- 0-52 McNeil Island
- 0-53 Harstene Island
- 0-54 West of Shelton (Goldsborough Cr.)
- 0-55 N. W. Shelton
- 0-56 S. Fork Skokomish River
- 0-57 N. Fork Skokomish River
- 0-58 W. Hood Canal
- 0-59 Tahuya River
- 0-60 N. Hood Canal
- 0-62 Carr Inlet Area
- 0-63 Vashon Island
- 0-66 Hamma Hamma River
- 0-67 Dosewallips-Duckabush
- 0-68 E. Hood Canal
- 0-69 West Kitsap Area
- 0-70 East Kitsap Area
- 0-71 Quilcene
- 0-72 East Jefferson
- 0-73 Chimacum Creek
- 0-75 Sequim Bay Area
- 0-76 Johnson Creek
- (0-0) WATERSHED BOUNDARY



LEGEND

- PRESENT BUILT-UP AREAS
- BUILT-UP AREAS, YEAR 2020
- FOREST
- RURAL NON-FARM
- CROPLAND
- RANGE
- UNPRODUCTIVE FOREST LAND
- RESERVED PRODUCTIVE FOREST LAND
- GRASS, BRUSH, & BARRENS
- 100 YEAR FLOOD PLAIN



LOCATION MAP

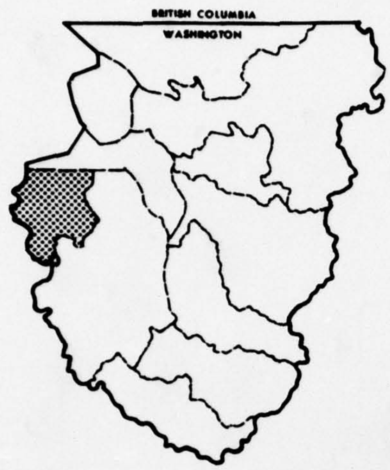
FIGURE 7-45

WEST SOUND BASINS

GENERALIZED LAND USE MAP

Alternative C2 - 2020

ELWHA-DUNGENESS BASINS



The Elwha-Dungeness Basins are located in the west sector of the Puget Sound Area fronting on the Strait of Juan de Fuca in eastern Clallam and Jefferson Counties. The Basins contain a hydrologic area of some 448,457 acres, of which 60%, the entire southern segment, is within the Olympic National Park. Major drainages include the Elwha River with many small tributaries, mostly in the National Park; and the Dungeness River with its major tributary, the Greywolf River, mostly in the Olympic National Forest. Smaller streams entering directly into the Straits of Juan de Fuca include McDonald Creek and Ennis Creek.

Population

The population of the Basins in 1967 was 28,500 persons. This population is primarily located in the cities and towns along the Strait of Juan de Fuca. Projections show that the population will grow to 29,800 by 1980, 41,000 by 2000 and 56,600 persons by the year 2020.

Land Use

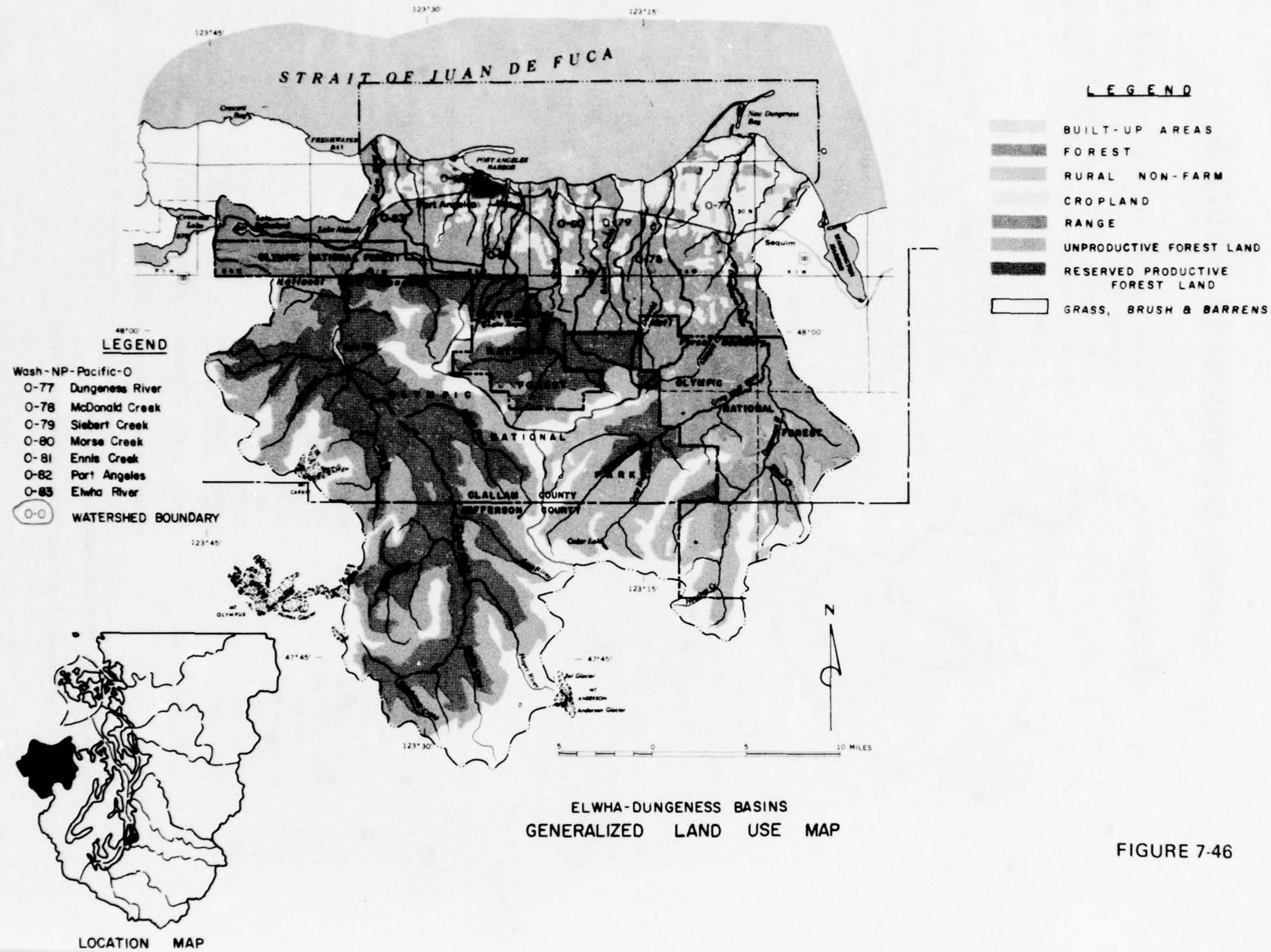
The primary land use in the Elwha-Dungeness Basins, as is true of the total Study Area, is forests and associated lands which accounts for 90% of the total land cover. The other two major uses, croplands and urban or intensive land uses, occupy 5% and 1% of the land, respectively. Table 7-61 shows the tabulation of present land use within the Basins. Figure 7-46, the generalized land use map of the Elwha-Dungeness Basins, portrays the land areas occupied by each of the major uses.

TABLE 7-61. Land use in Elwha-Dungeness Basins (acres)[1]

Map No.	Watershed	Crop-land	Range-land	Total Forest[2]	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
0-77	Dungeness River	14,936	975	119,500	2,266	967	361	139,005
0-78	McDonald Creek	1,955	241	13,580	103	74	4	15,957
0-79	Siebert Creek	2,100	210	12,435	196	136	2	15,079
0-80	Morse Creek	2,402	475	41,780	1,185	411	55	46,308
0-81	Ennis Creek	152	180	5,193	199	352	8	6,084
0-82	Port Angeles	1,424	232	10,062	892	3,630	8	16,248
0-83	Elwha River	752	104	206,941	232	341	1,406	209,776
	Total Pacific Drainages	23,721	2,417	409,491	5,073	5,911	1,844	448,457
	Elwha-Dungeness	23,721	2,417	409,491	5,073	5,911	1,844	448,457

1 Unadjusted measurements, 1966, for Puget Sound Area Study.

2 Figures include nonforested land commonly associated with forest areas.



ELWHA-DUNGENESS BASINS
GENERALIZED LAND USE MAP

FIGURE 7-46

AGRICULTURE

PRESENT STATUS AND POTENTIAL

The Elwha-Dungeness Basins are located largely in Clallam County, with approximately one-fourth of their area being in northeastern Jefferson County.

Four-fifths of the area is rugged mountainous terrain, and the remainder, along the northern coast, is made up largely of alluvial terraces.

Of the total land area of 446,613 acres in the Basins, those lands outside the national forest and park have been mapped by a medium-intensity soil survey. Lands within the national forest and national park have been mapped by a low-intensity soil survey suitable for reconnaissance use. Of the 108,317 acres of land mapped in the medium-intensity survey, approximately 73,000 acres are classified in Land Use Capability Classes II through VI.

These 73,000 acres make up the land which has the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, and IV are suited for either cropland or urban uses, and Class VI has potential for urban developments.

The Dungeness River has its headwaters high in the Olympic Mountains, and flows northerly, where it empties into the Strait of Juan de Fuca. It drains an area of about 217 square miles. The principal tributary is Gray Wolf River, which joins the Dungeness River within the confines of the Olympic National Forest.

The Elwha River has its source in the glaciers of the Olympic Mountains. It flows in a northerly direction and discharges into the Strait of Juan de Fuca. The Elwha River drains approximately 328 square miles. There are no tributaries of importance.

Overall, the Elwha-Dungeness Basins drain about 700 square miles. The system includes many flood and drainage problem areas which require corrective measures before their potential can be attained. The combined flood plain of the two major rivers contains about 3,000 acres of gently undulating river bottom lands. Most of the farm land is situated on alluvial terraces above the flood plain. The upper reaches of the Basins are steep, mountainous valleys with turbulent streams. Much of the area of the Elwha-Dungeness Basins lies within the Olympic National Park.

Production

The raising of dairy and beef cattle is the principal farming enterprise, and most of the acreage is seeded pasture or hayland. Field crops, peas in particular, make a significant contribution to the farming economy. Total value of farm production in the Elwha-Dungeness Basins is more than $2.5 million annually.

Forests use by far the largest area of land in the Basins, comprising more than 90 percent of the total. Several large mills are located within the Basins.

Flooding

Climatic conditions induce one flood-producing season annually in the fall or winter as a result of excessive precipitation.

Discharges in excess of channel capacity cause water to spread across the valley, where it remains until the river drops. In many areas, water is trapped by topographic detail until it can seep into the soil. Excessive rainfall causes similar flooding conditions, as well as swamping of the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV. Principles and conditions discussed therein apply to the Elwha-Dungeness Basins and need not be repeated here.

Watersheds

Seven watershed areas requiring solutions to problems, or development to achieve potential productivity of the Elwha-Dungeness Basins, are shown on the Land Use Map (Figure 7-46) and on the Land Capability Map (Figure 7-47).

Dungeness River watershed (0-77) contains more than half of the cropland in the Basins and a large portion of the forest land. Raising of dairy and beef cattle is the principal farming enterprise, and most of the cropland consists of seeded pasture or hayland. Almost 90 percent of the forested lands are in the Olympic National Park and the Olympic National Forest. Except for the town of Sequim, urbanization has had very little impact upon the watershed. Potential use would seem to be in the further development of cropland and, to a lesser extent, forestry.

McDonald Creek watershed (0-78) is one of the smaller watersheds in the Basins. It contains approximately 16,000 acres, of which 85 percent is in forest. The cultivated portion of the watershed is small, consisting of about 2,000 acres. Built-up areas are virtually nonexistent. Potential use probably will continue to be logging, with minor emphasis on cropland development.

Siebert Creek watershed (0-79) has approximately the same characteristics as McDonald Creek watershed and its potential use is about the same.

Morse Creek watershed (0-80) is heavily forested, with more than half the watershed lying in the Olympic National Park. There are approximately 2,500 acres of cropland, predominantly hay and pasture. Urban development from Port Angeles is beginning to spill over into the lower portion of the watershed; also, a large number of urban residences have been constructed along the west side of Morse Creek. Potential use would seem to lie in continued urbanization and commercial development. Forestry and farming should continue to be important.

Ennis Creek watershed (0-81) is largely forest-covered. Nearly all of the cleared and cultivated land has been taken over by urban development. Potential use probably will be for continued urban expansion, with minor emphasis on forestry.

Port Angeles watershed (0-82) is heavily forested in its upper reaches and heavily urbanized in its lower portions. There are about 1,400 acres of farm lands. Potential use would seem to be continued commercial and urban development.

Elwha River watershed (0-83) is the largest watershed in the Basins. Almost 99 percent of its total area is in forest, with the bulk of that being either national forest or national park. Farming and urban areas are almost nonexistent. Potential use probably will be the continued development of forested lands.

Many of the farm lands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these conditions are summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the Elwha-Dungeness Basins is shown in Table 7-61. The following tables are to indicate the potential development possible within acceptable land use standards.

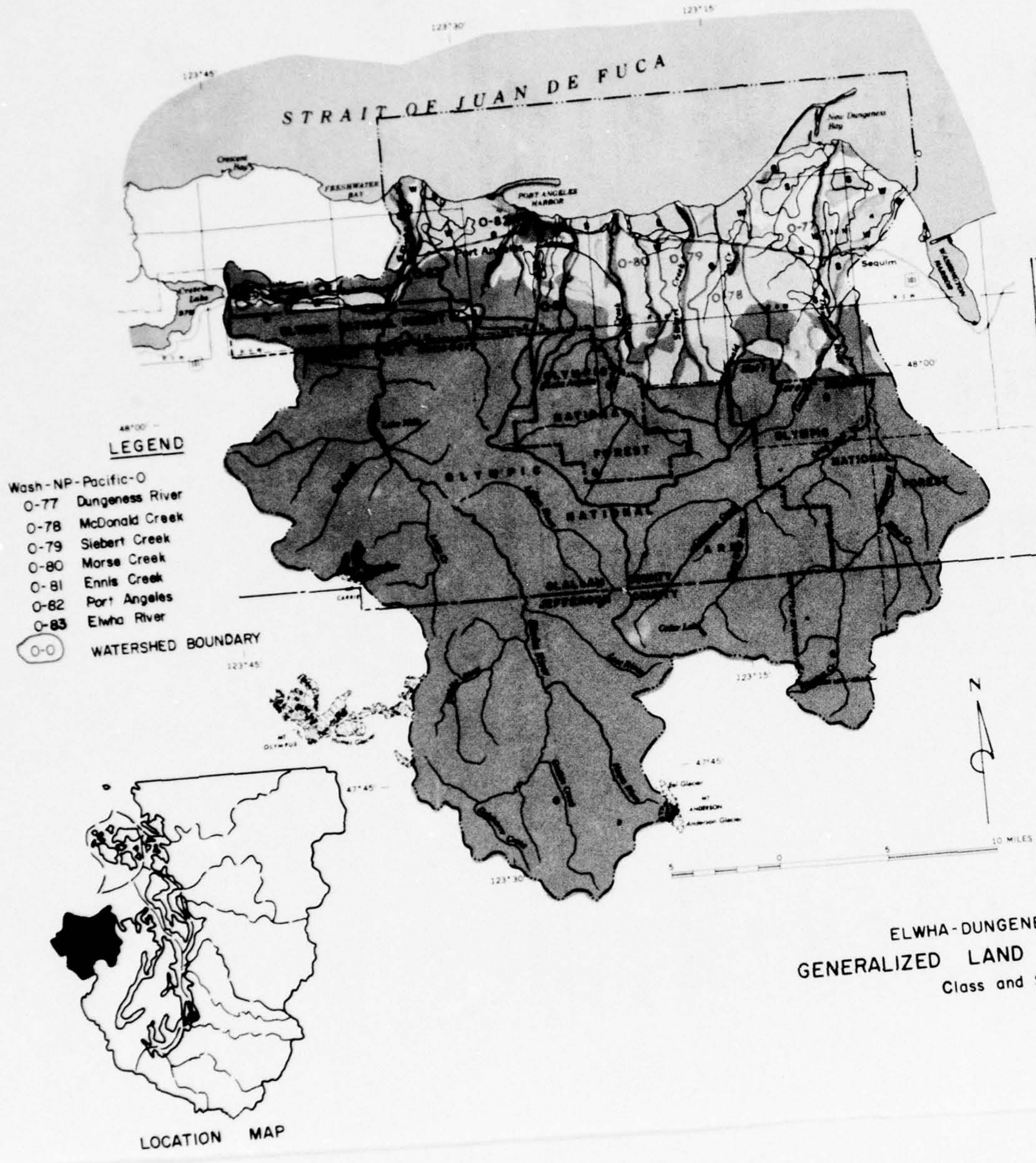
Table 7-62 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-63 shows the number of acres in each capability class, subclass, and unit, by watersheds in the Elwha-Dungeness Basins. This table can be used with the description of capability units to estimate the potential for development.

TABLE 7-62. Distribution and value of production by crops in Elwha-Dungeness Basins

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	340	401	1.69	19,345	.99
Field crops	215	253	1.07	75,554	3.86
Vegetables	98	116	.49	24,912	1.27
Berries	69	81	.34	83,259	4.25
Nursery products	3	3	.01	5,233	.27
Cropland not used	714	841	3.55	--	--
Sub-Total	1,439	1,695	7.15	208,303	10.64
Hay	8,784	10,356	43.66	485,416	24.79
Hay aftermath	--	--	--	399,008	20.37
Sub-Total	8,784	10,356	43.66	884,424	45.16
Silage (grass)	1,761	2,077	8.75	137,606	7.03
Grass aftermath	--	--	--	80,020	4.09
Sub-Total	1,761	2,077	8.75	217,626	11.12
Silage (corn) fodder	76	90	.38	5,964	.30
Pasture (cropland)	8,060	9,503	40.06	641,830	32.78
Sub-Total	18,681	22,026	92.85	1,749,844	89.36
Total	20,120	23,721	100.00	1,958,147	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.



LEGEND

LAND SUITED FOR CULTIVATION AND OTHER USES

I — Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.

II — Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

III — Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.

IV — Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

V — Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.

VI — Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.

VII — Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.

VIII — Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.

ELWHA-DUNGENESS BASINS
GENERALIZED LAND CAPABILITY MAP
Class and Subclass

FIGURE 7-47

TABLE 7-63. Land capability units in Elwha-Dungeness Basins (acres) [1]

Capability Units[2]	WATERSHEDS 0-77	0-78	0-79	0-80	0-81	0-82	0-83	Total
II ws 03	5,796	180		95			226	6,297
II ws 04	1,151		2	30	52	57	25	1,317
II ws 06	300	8	196	48	9	17	232	810
II Total	7,247	188	198	173	61	74	483	8,424
III ew 03	6,472	4,107	4,016	6,744	934	1,487		23,760
III ws 04	1,438							1,438
III ws 10	1,151	197	433	525	68	376		2,750
III so 06	2,278	410	210			5		2,903
III Total	11,339	4,714	4,659	7,269	1,002	1,868		30,851
IV ew 03	1,561	703	27	740	326	5,871	839	10,067
IV ws 01	1,163	3		38			481	1,685
IV ws 06				30				30
IV ws 10	54	20	10					84
IV ws 13	1,369	1,250	1,070	167	37	931	404	5,228
IV so 01	71	130	16	614	135	321	931	2,218
IV so 10	1,628							1,628
IV Total	5,846	2,106	1,123	1,589	498	7,123	2,655	20,940
II-IV Total	24,432	7,008	5,980	9,031	1,561	9,065	3,138	60,215

1 Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include land within national forest or park boundaries.

2 See Exhibit 1 for description of capability units.

TABLE 7-63. Land capability units in Elwha-Dungeness Basins (acres)[1] (cont.)

Capability Units[2]	WATERSHEDS 0-77	0-78	0-79	0-80	0-81	8-82	0-83	Total
VI ew 23	1,191	1,213	2,762	1,933	259	740	475	8,573
VI so 10	1,040							1,040
VI so 18	956	80	617	786	88	111	433	3,071
VI Total	3,187	1,293	3,379	2,719	347	851	908	12,685
VII ew 32	655							655
VII es 36	4,189	2,464	2,462	5,698	1,955	5,830	9,221	31,819
VII Total	4,844	2,464	2,462	5,698	1,955	5,830	9,221	32,474
VIII ew 39	1,122			84	32	441	86	1,765
VIII ws 00	378	55		33			313	779
VIII ws 23	110							110
VIII ws 24	185	7	11	15		53	19	290
VIII Total	1,795	62	11	132	32	494	418	2,944
II-VIIITotal	9,826	3,819	5,852	8,549	2,334	7,175	10,547	48,102
II-VIII Total	34,258	10,827	11,832	17,580	3,895	16,240	13,685	108,317

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps. Does not include land within national forest or park boundaries.

[2] *See Exhibit 1 for descriptiong of capability units.*

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the Elwha-Dungeness Basins will increase from 28,500 people in 1967 to 56,600 in 2020, according to Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 10,984 acres presently in intensive and rural nonagricultural use could provide ample acreage for new intensive development to the year 2020 without an encroachment onto the croplands of the Basins.

Cropland Needs

The Basins presently have 23,721 acres of cropland. This acreage is expected to remain fairly constant, with approximately 24,000 acres foreseen for 2020. The percent increases needed, by crops, for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Table 7-64 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the Elwha-Dungeness Basins is summarized under the topic "Program Implementation" immediately following "Forestry." A more complete description is found in Appendix XIV, Watershed Management.

TABLE 7-64. Protection and development needs

Measures Needed	*Unit*	*1980*	*2000*	*2020*
Floodwater protection[1]	acre	13,747	13,747	13,747
Watershed protection and rehabilitation[2]	acre	26,278	26,348	26,417
Drainage improvement	acre	9,644	16,073	21,430
Irrigation development[3]	acre	17,000	18,000	22,000
Water for irrigation[4]	ac.ft.	46,580	49,320	60,280

[1] A total of 15,888 acres in the Elwha-Dungeness Basins are subject to flooding. Only the amount of cropland needing protection through 2020 has been evaluated here.

[2] Includes 2,417 acres of rangeland.

[3] According to Appendix VII, Irrigation, there were 15,900 acres (using 43,566 acre-feet of water) irrigated in 1966. Irrigation Appendix projections show 21,900 acres irrigated by 1980; 21,900 acres by 2000; and 21,900 acres by 2020.

[4] Based on gross diversion requirements of 2.74 acre-feet per acre estimated by the Irrigation Committee in Appendix VII, Irrigation.

FORESTS

PRESENT STATUS

Most of the land in the Elwha-Dungeness Basins is classified as forest land. Area in this class is 342,160* acres, or 77% of the Basins' total hydrologic area (Table 7-65). The continuous forest areas are located in the National Park and National Forest with scattered smaller tracts along the flats between the Federal boundaries and the Strait of Juan de Fuca. A great portion of the forest land, 221,900 acres, is in a reserved status under the administration of the National Park Service. The remaining available forest land is divided into the resource zones shown below:

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	32,820	27
Principal Forest	72,690	61
Upper Forest	4,610	4
Subalpine	10,140	8
Total available	120,260	100

*Does not include nonforested lands commonly associated with forest areas.

TABLE 7-65. Elwha-Dungeness Basins—Area of forest land, in acres, by ownership and type

Cover Type or Land Class	Available National Forest	Available State & County	Available Muni-cipal	Available Private	Available Total Avail-able	Unavail-able	Total Avail. & Unavail.
Douglas fir							
seedlings and saplings	550	1,650	--	2,390	4,590	19,400	23,990
poletimber	10,360	16,600	40	7,200	34,200	7,660	41,860
small young growth sawtimber	4,350	3,320	20	4,800	12,490	800	13,290
old growth and large young growth sawtimber	11,800	--	10	--	11,810	46,840	58,650
True fir-mountain hemlock							
seedlings and saplings	1,410	--	--	--	1,410	--	1,410
poletimber	420	--	--	--	420	--	420
small sawtimber	470	--	--	--	470	5,210	5,680
large sawtimber	2,280	--	30	--	2,310	13,440	15,750
Western hemlock							
seedlings and saplings	1,410	--	10	--	1,420	1,790	3,210
poletimber	2,350	--	10	2,410	4,770	390	5,160
small sawtimber	1,980	--	--	--	1,980	1,350	3,330
large sawtimber	2,680	--	10	--	2,690	13,930	16,620
Western redcedar							
seedlings and saplings	100	--	--	--	100	--	100
poletimber	--	--	--	2,370	2,370	--	2,370
small sawtimber	470	--	--	--	470	--	470
large sawtimber	2,350	--	--	--	2,350	--	2,350
Lodgepole pine							
seedlings and saplings	310	--	--	--	310	410	720
White fir							
poletimber	80	--	--	2,170	2,250	20	2,270
SUBTOTAL, softwoods	43,370	21,570	130	21,340	86,410	111,240	197,650
Hardwoods							
seedlings and saplings	--	--	--	2,640	2,640	--	2,640
poletimber	510	3,320	20	4,650	8,500	80	8,580
small sawtimber	1,290	--	--	4,950	6,240	390	6,630
large sawtimber	--	--	--	--	--	--	--
SUBTOTAL, hardwoods	1,800	3,320	20	12,240	17,380	470	17,850
Nonstocked							
cutover	560	--	--	--	560	--	560
deforested by fire	120	--	--	--	120	1,030	1,150
SUBTOTAL, nonstocked	680	--	--	--	680	1,030	1,710
TOTAL, productive land	45,850	24,890	150	33,580	104,470	112,740	217,210
Subalpine	10,140	--	--	--	10,140	102,690	112,830
Noncommercial, rocky	5,650	--			5,650	6,470	12,120
TOTAL, unproductive land	15,790	--	--	--	15,790	109,160	124,950
TOTAL, all forested land	61,640	24,890	150	33,580	120,260	221,900	342,160

Commercial forest land capable of producing continuous crops of industrial wood amounts to 104,470 acres in the Elwha-Dungeness Basins. The sawtimber inventory on these lands is 1.6 billion board feet, International ¼-inch Rule (Table 7-66). The figures represent 2% of Puget Sound Area's commercial forest land and 1.5% of its sawtimber volume. Private lands, located almost entirely in the north one-third of the Basins, contain 32% of the commercial forest area. Large corporate holdings make up only 760 acres of the total. There are no medium-sized ownerships. The bulk of the private commercial forest area is in small ownerships totaling 32,820 acres. Public commercial forest lands are located in the foothill areas fronting on the Olympic National Park. These areas contain 45,850 acres in National Forest ownership (65%), and 24,890 acres in State and county ownership (35%).

The forest products industry supported by the Elwha-Dungeness Basins is rather small due to the large area of reserved lands. All except two of the ten manufacturing plants are located at Port Angeles. The two exceptions are the sawmills at Carlsborg and Sequim. All of the ten plants are classed as sawmills. Products, aside from lumber, are chips, car stock, studding, shakes and shingles, poles and piling, and veneer. These manufacturing plants require over 300,000 board feet of raw material each day. In addition, a plywood plant in Port Angeles secures a substantial portion of its log supply from Elwha-Dungeness Basins.

Problems affecting forest land management and industrial development are similar to those found throughout the Puget Sound Area. Road location and construction presents special problems in the Dungeness River area due to the unstable clay soils. Industrial development is hampered by lack of sufficient harbor front lands in Port Angeles.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

No determination of the demand for wood products is made specifically for the Elwha-Dungeness Basins. The nature of the forest products industries, particularly the relative ease of log transportation between the Basins, would make such a determination rather meaningless. In addition, a specific figure would imply that a production goal was established for the Basins, which is not the case. Production goals are established for the Puget Sound Area as a whole, with the assumption that considerable shifts in production between the Basins will occur, depending upon the actual pattern of industrial and land use development.

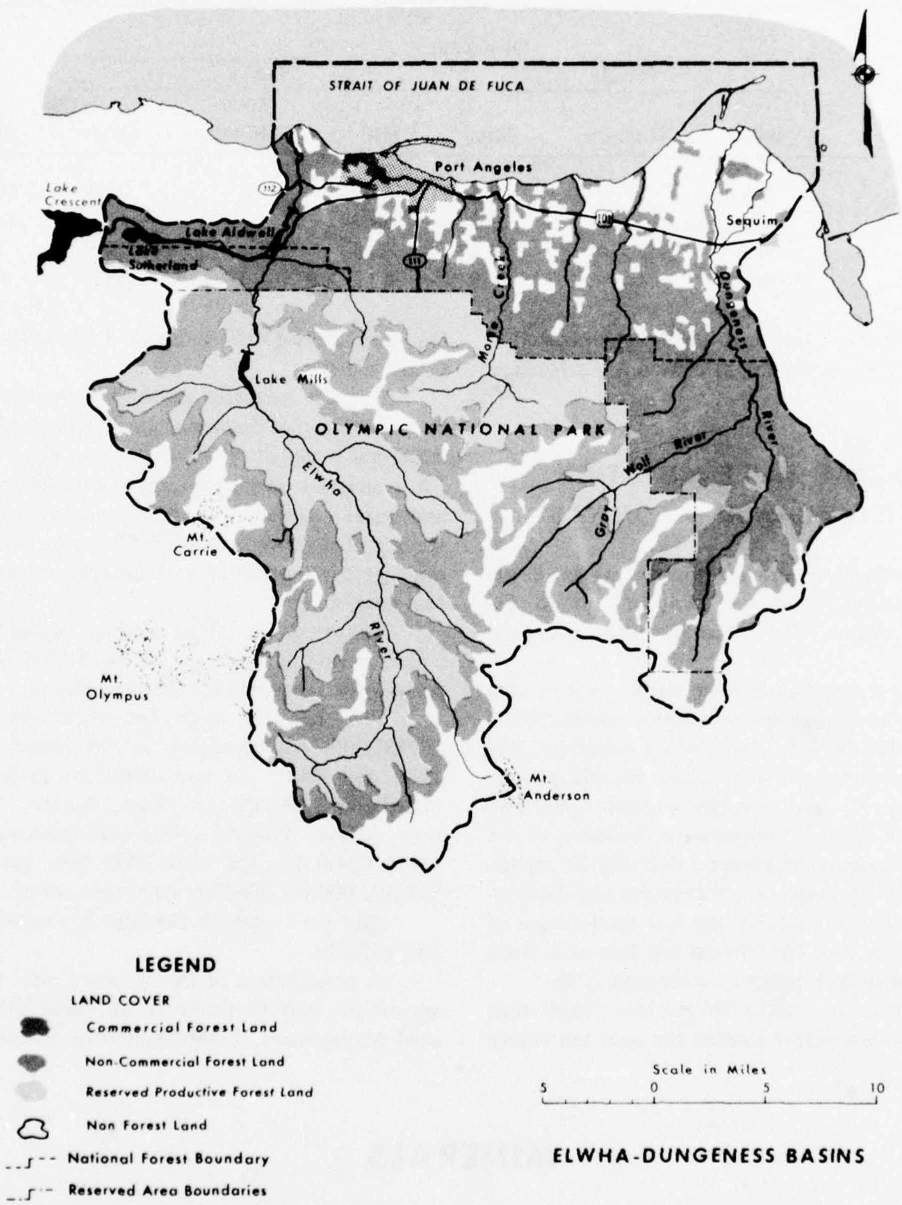
For sake of basin comparison, however, there is some value in showing the percentage of demand that may be supplied by the Elwha-Dungeness Basins in the future. In 2020, the Basins are expected to contain about 2% of the commercial forest land in the Puget Sound Area. The percentage in earlier periods is slightly lower. It is, therefore, assumed that the Basins will supply approximately 2% of the total wood products demand in the future.

The effect of competing uses for forest lands is discussed in detail in the section covering the Puget Sound Area. The estimated diversion of forest land from these causes in the Elwha-Dungeness Basins is shown below:

Type of Land Diversion	Acres Diverted (2020)
Parks, Wilderness, Campgrounds or other Recreation Use	1,210
Roads and Highways	4,870
Urban-Industrial Development	4,930
Reservoirs, Powerlines, and other miscellaneous conversion	--
Private Land Use Reservations	5,000
Total	16,010

TABLE 7-66. Elwha-Dungeness Basin—Volume of sawtimber and growing stock, by ownership, on productive forest land

Species or Group	Available						
	National Forest	State & County	Municipal	Private	Total Available	Unavailable	Total Available & Unavailable
Sawtimber—Thousand board feet, International ¼-inch Rule							
Douglas-fir							
small sawtimber	79,200	73,780	360	77,930	231,270	33,020	264,290
large sawtimber	660,060	25,170	590	11,350	697,170	2,668,800	3,365,970
True fir—mountain hemlock							
small sawtimber	9,470	--	--	--	9,470	93,790	103,260
large sawtimber	141,540	--	1,630	--	143,170	761,550	904,720
Western hemlock							
small sawtimber	33,840	--	20	3,230	37,090	25,820	62,910
large sawtimber	144,950	--	560	3,230	148,740	790,840	939,580
Western redcedar							
small sawtimber	9,720	--	--	3,260	12,980	--	12,980
large sawtimber	210,380	--	--	3,270	213,650	--	213,650
Other softwood species							
small sawtimber	280	--	--	3,530	3,810	230	4,040
large sawtimber	290	--	--	3,530	3,820	240	4,060
SUBTOTAL, softwoods	1,289,730	98,950	3,160	109,330	1,501,170	4,374,290	5,875,460
Hardwoods							
small sawtimber	13,830	3,340	10	53,500	70,680	5,060	75,740
large sawtimber	620	3,350	20	5,230	9,220	80	9,300
SUBTOTAL, hardwoods	14,450	6,690	30	58,730	79,900	5,140	85,040
TOTAL SAWTIMBER, all species	1,304,180	105,640	3,190	168,060	1,581,070	4,379,430	5,960,500
Growing stock—Million cubic feet							
Douglas-fir	134.7	18.0	0.2	16.3	169.2	492.2	661.4
True fir-mountain hemlock	27.3	--	0.3	--	27.6	154.7	182.3
Western hemlock	34.8	--	0.1	1.3	36.2	159.1	195.3
Other softwood species	87.4	--	--	5.4	92.8	0.2	93.0
SUBTOTAL, softwoods	284.2	18.0	0.6	23.0	325.8	806.2	1,132.0
Hardwoods	5.7	2.6	0.0	23.2	31.5	2.0	33.5
TOTAL GROWING STOCK, all species	289.9	20.6	0.6	46.2	357.3	808.2	1.165.5



ELWHA-DUNGENESS BASINS

FORESTS

FIGURE 7-48. Forest lands in the Elwha-Dungeness Basins

The current and prospective changes in the commercial forest land base from all causes are given below:

Current and projected commercial forest area in the Elwha-Dungeness Basins 1965-2020 (in thousand acres)

	Ownership						
	Private			Public			
Period	Large	Medium	Small	NF	Other Federal	Other	Total
1965	0.8	--	32.8	45.9	--	25.0	104.5
1980	2.0	--	29.3	44.7	--	24.6	100.6
2000	4.3	--	23.1	43.5	--	24.1	95.0
2020	5.5	--	17.3	42.2	--	23.6	88.6

Specific measures for soil and water protection are discussed in Appendix XIV, Watershed Management.

PROGRAM IMPLEMENTATION AGRICULTURE AND FORESTS

To sufficiently provide for the needs of the Elwha-Dungeness Basins, as brought out in the preceding section, the following plan has been designed.

The plan, multi-purpose in nature, will provide for floodwater damage prevention, watershed protection and rehabilitation, drainage improvement, and irrigation development. Other measures will provide for water quality and quantity control, recreation, and fish and wildlife development. Included in the plan are programs and projects designed to accomplish specific objectives of conservation and development. The plan provides for the full development of lands presently used for farming and that such lands will continue in their present use through 2020.

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000); and (c) distant future (2000-2020).

Program measures are on-site practices which take advantage of developments made possible by the structural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management, and irrigation development.

The total cost of the program during the early action period is expected to be $12,910,000. No projects are scheduled for this time period.

Five projects, with an installation cost of $2,962,000, are scheduled for the period between 1980 and 2000; and two additional projects, estimated cost $300,000, are planned for the 2000-2020 time period. Program costs are expected to be $18,428,000 for the 1980-2000 time period, and $19,352,000 for the 2000-2020 time period.

The total cost of the plan is expected to be $53,952,000.

A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, Watershed Management, Elwha-Dungeness Basins section.

MINERALS

The Elwha-Dungeness Basins are most important for their manganese production. Other mineral commodities that have been or are being produced are mineral water, stone, and sand and gravel. Peat also occurs.

The locations of the known mineral deposits in the Basins are shown on Figure 7-49. The open circles on the maps indicate properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been

made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

Stone

Stone has been produced from three quarries—two in basalt and one in sandstone. One quarry is active intermittently at the present time (1966). Production statistics are not available, nor is there an estimate of reserves.

Sand and Gravel

Most of the northern border of the Basins is mantled with glacial material (Figure 7-49), much of which might serve as sources of sand and gravel. Twenty-nine pits have been productive in the area at one time or another, but at the present time (1966), only 4 pits are being operated.

Sand and gravel production statistics are not available. Reserves are adequate for many years at the present rate of consumption.

Mineral Water

A group of 21 mineral springs that have a large flow of hot sulfur water has been developed at the Olympic Hot Springs resort (Figure 7-49). The water is used for bathing and swimming facilities.

Manganese

Three of 32 manganese properties have a record of production. These are the Crescent, Hurricane, and Bright Angel mines.

The Crescent mine (Figure 7-49, No. 89) produced 16,275 tons of ore from 1924 to 1926, and about 33,500 tons from 1941 to 1946. Small shipments were made in 1952 and 1953. The ore body consisted of three lenses of manganese ore in limestone and volcanic rocks. Two of the lenses have been mined out, and no estimate of the reserves in the remaining lens is available. Assays on the shipments made from 1941 to 1946 averaged about 51.6 percent manganese, 1.6 percent iron, 9.1 percent SiO_2, 0.05 percent phosphorus, and 4 percent water.

A reported 1,000 tons of high-grade manganese ore was shipped from the Hurricane mine (Figure 7-49, No. 91). The ore deposit is similar to that at the Crescent mine.

The Bright Angel mine (Figure 7-49, No. 90) is reported to have shipped ore, but no other information on the property is available.

Peat

Two peat bogs totaling over 150 acres have been examined in the area. No production of peat has been reported.

INTENSIVE LAND USE

The Elwha-Dungeness Basins are located in northwest Washington and contain two independent basins and a number of smaller streams draining the northern slopes of the Olympic Mountains and discharging into the Strait of Juan de Fuca. At the present time, Port Angeles and Sequim are the only incorporated cities.

INCORPORATED CITIES

Port Angeles

The city of Port Angeles, county seat of Clallam County, is located on the Strait of Juan de Fuca, 98 miles northwest of Seattle, opposite Victoria, British Columbia, and at the base of the Olympic Mountains. The city had its beginnings in 1862 when it was designated "the second national city" by President Abraham Lincoln, who, on June 19, signed an executive order creating the government reservation of Port Angeles and Ediz Hook for lighthouse, military, and naval reserve and other public purposes after Congress had enacted legislation making Port Angeles an official customs port of entry. It was almost 15 years before much growth occurred and in 1890, the municipality was incorporated.

As the gateway to Puget Sound, Canada, and the Olympia National Park, Port Angeles is a tourist and recreation area, but the primary industries are found in the areas of pulp and paper, paper products, logging, lumber and wood products, manufacturing construction materials, fishing and shipping. The city's population has increased from 9,409 in 1940 to 11,233 in 1950, to 12,653 in 1960, and to 15,800 in 1967.

Sequim

The city of Sequim, sunniest and dryest area in Western Washington, is in the northeast corner of the Olympic Peninsula with the Strait of Juan de Fuca to the north and the Olympic Mountains to the south. Although settlers first arrived in 1851, the town was not incorporated until 1913. Large dairy herds and the many irrigated farms nearby help make Sequim a marketing center for the Sequim-Dungeness Valley. Sequim's 1950 population was reported as 1,044 and by 1967, had increased to 1,450.

Unincorporated towns in the Elwha-Dungeness Basins include Elwha, Dungeness, Agnew, Heart of the Hills, and Carlsborg.

TRANSPORTATION

Rail–The Milwaukee Railroad runs from Port Angeles east to Port Townsend, where railroad cars are then transported by barges across Puget Sound to Seattle.

Highways–U.S. Highway 101 runs from east to west across the Basins. State Highway 112 follows the coast, and also runs from east to west. Secondary roads provide access south into Olympic National Park and Olympic National Forest.

Airways–The only commercial air service in the Basins is at Port Angeles.

Navigation–Port facilities at Port Angeles accommodate ocean-going ships as well as sport and commercial fishing boats. There are also several minor ports for ferryboats and pleasure craft situated along the coast.

LAND USE CHARACTERISTICS

There are 446,613 acres in the Elwha-Dungeness Basins and 1,844 acres of inland water. Table 7-61 contains the figures showing the acreages of the major land use acreages within the Basins.

Figure 7-46 portrays the land use pattern for the Elwha-Dungeness Basins. It can easily be seen from this map that primary use of land in the Basins presently is forest use, with a large portion of these forested lands being contained within the Olympic National Forest and Olympic National Park.

Intensive Land Use

At the present time (1967) intensive land uses occupy some 5,911 acres or 1.3 percent of the Basins' land area. Nearly all of the intensive land use area is in or around Port Angeles and Sequim, although a few intensive uses will be found at scattered locations throughout the Basins. The following list contains the land use figures for the intensive land use subgroups.

Railroads	Roadways	Airports	Urban (Built-up)	Total
230	1,335	413	3,933	5,911

Rural Nonagricultural

Many of the land uses classified within the rural nonagricultural category are similar in character and often associated with or are the forerunners of intensive land use. The following list contains the acreages of the several subgroups in the rural nonagricultural category.

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm yards)	Total
2,489	988	61	1,535	5,073

Land Ownership

Of the total land area (446,613 acres) in the Elwha-Dungeness Basins, 16.0 percent is in private ownership and 2.3 percent in private corporate ownership, 75.5 percent in Federal ownership, 5.7 percent in State ownership, and .5 percent in local government ownership. The bulk of the private corporate, Federal and State ownerships are forested and park areas, including a large portion in Olympic National Park. Land area owned by local government is almost exclusively in the northern portion of the Basins around Port Angeles and consists mainly of streets, facilities, local parks, and similar areas. Other (nonforest) private ownerships, also mainly in the northern part of the Basins, consist essentially of intensive, rural nonagricultural and agricultural land areas.

TRENDS AND POTENTIALS

Intensive land use in the Elwha-Dungeness Basins amounts to some 5,911 acres or approximately one-fourth of a township. This area accounts for less than 1 percent of the total Basins' area. Present

requirements for intensive land uses are being filled in and around the city of Port Angeles and Sequim in the northern portion of the Basins. Within the Elwha-Dungeness Basins, there is likely to be only a small demand for intensive development. Some future intensive development will occur in and around the city of Port Angeles and the city of Sequim. Other minor intensive uses may be located along the Strait of Juan de Fuca in the northern portion of the Basins. Future intensive development could eventually cover approximately one-half to three-fourths of a township (11,500-17,300 acres) in the Basins.

PRESENT AND FUTURE NEEDS

Intensive land use constitutes less than 1 percent of the total land acreage in the Basins. This is located primarily in and around Port Angeles and Sequim with some small scatterings along the Strait of Juan de Fuca. New growth to the year 2020 will primarily be in these existing locations.

Land needs for intensive land uses will be relatively small through the total planning period as population will increase by only 1,300 people by 1980; 13,000 by 2000; and 28,100 by the year 2020. This results in a need for 5,000 additional acres of land for intensive use by the end of the planning period. Figure 7-50 portrays the projected future land use pattern (C_2) for the Elwha-Dungeness Basins for the year 2020.

Growth will be seen in the pulp and paper products industry, but there will be a decline in the wood products lumber industry. It is felt there will be ample land designated for intensive uses to accommodate the industrial development.

The tourist industry will continue to expand within the Basins, and every effort should be made to exploit this economic opportunity through the development of proper facilities to accommodate the expanding recreation and tourist trade that will be brought to this area.

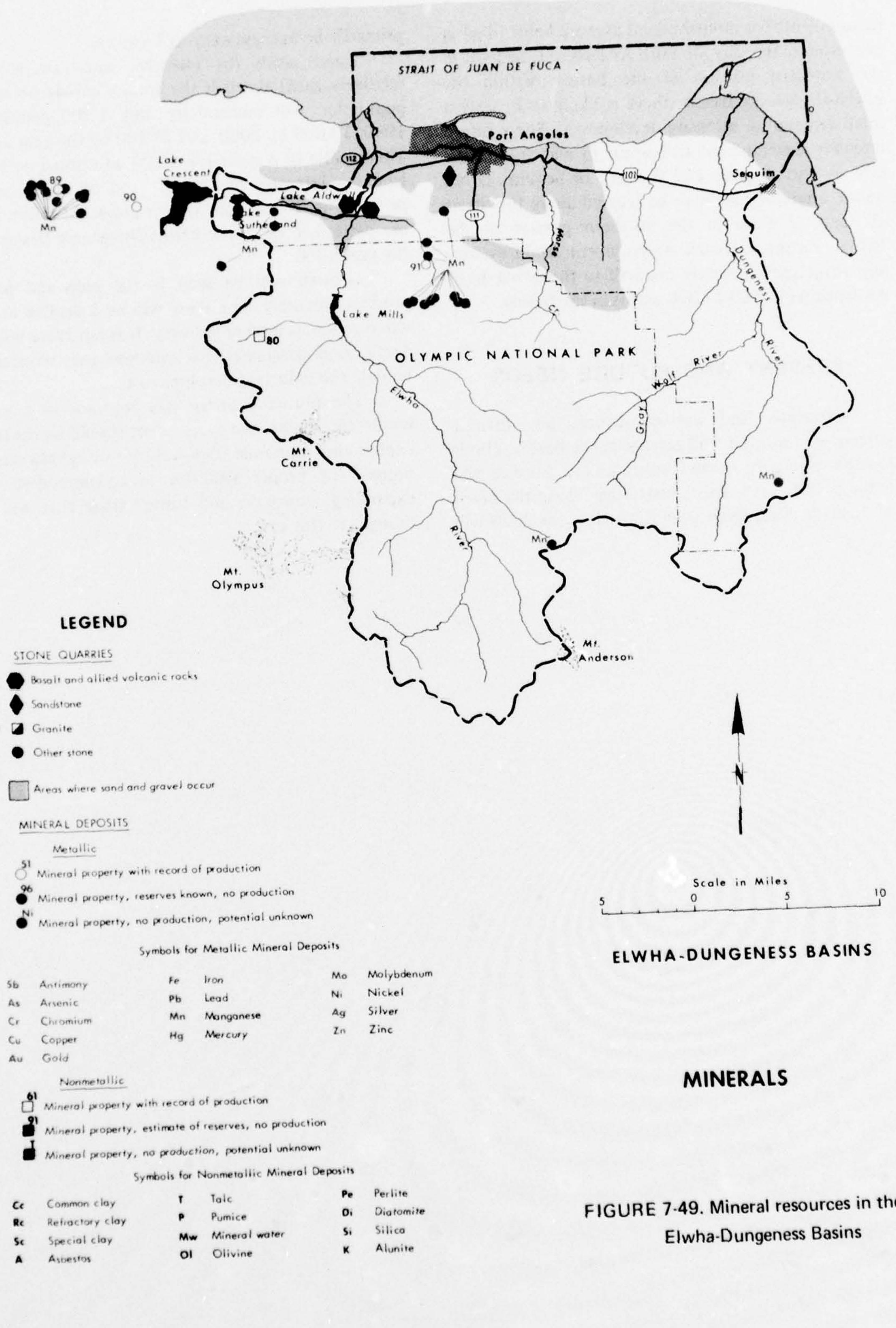


FIGURE 7-49. Mineral resources in the Elwha-Dungeness Basins

MINERAL PROPERTIES IN ELWHA-DUNGENESS BASINS*

Explanation for Figure 7-49

Metallic Minerals

(with production or reserves data where available)

Manganese (32 properties)

90	–	Bright Angel
89	–	Crescent (prod.–50,000 tons)
91	–	Hurricane (prod.–1,000 tons)

Nonmetallic Minerals

(with reserves data where available)

Mineral water (1 spring)

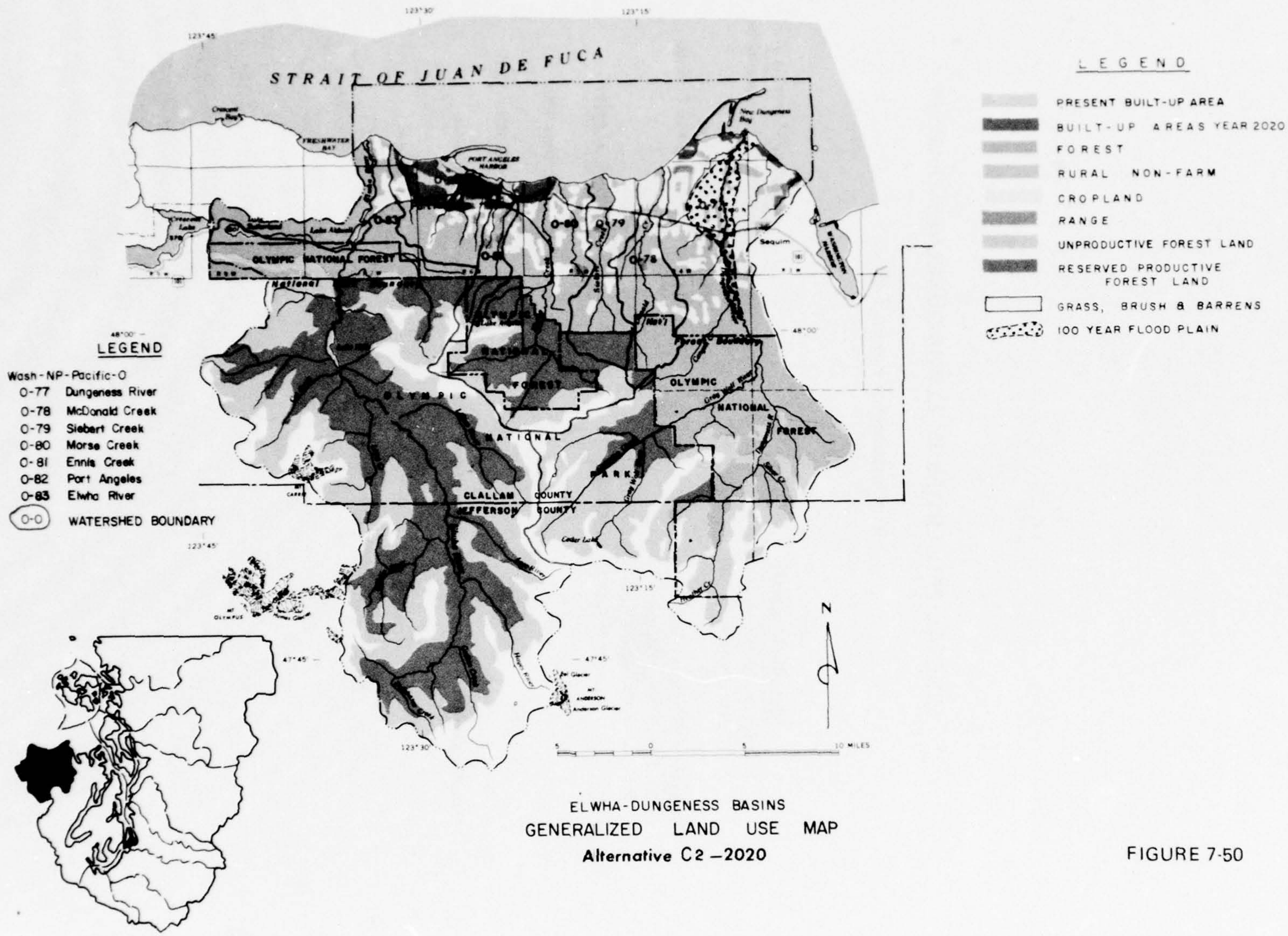
80	–	Olympic Hot Springs

Stone Deposits

Basalt (2 properties)

Sandstone (5 properties)

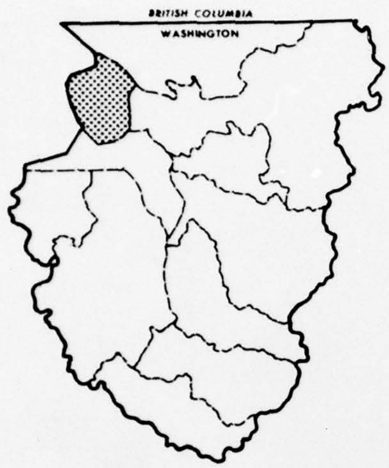
*Some properties not plotted on map because of poor description of location and/or lack of space.



ELWHA-DUNGENESS BASINS
GENERALIZED LAND USE MAP
Alternative C2 – 2020

FIGURE 7-50

SAN JUAN ISLANDS



The San Juan Islands are located in the north sector of the Puget Sound Area adjacent to the Canadian Border. They consist of 170 islands of which 20 islands are over 100 acres in size, that are situated between Haro and Rosario Straits. The three largest islands, which contain 81% of the land area, are Orcas, San Juan, and Lopez. The total hydrologic area of the group is 112,528 acres, all within San Juan County. Streams and lakes on these islands are small and do not add significantly to the water resources of Puget Sound Area.

Population

The population of the Islands in 1967 was 2,600 persons. Projections indicate that the population will grow to 2,800 by 1980, 3,700 by 2000 and to 5,100 persons by the year 2020.

Land Use

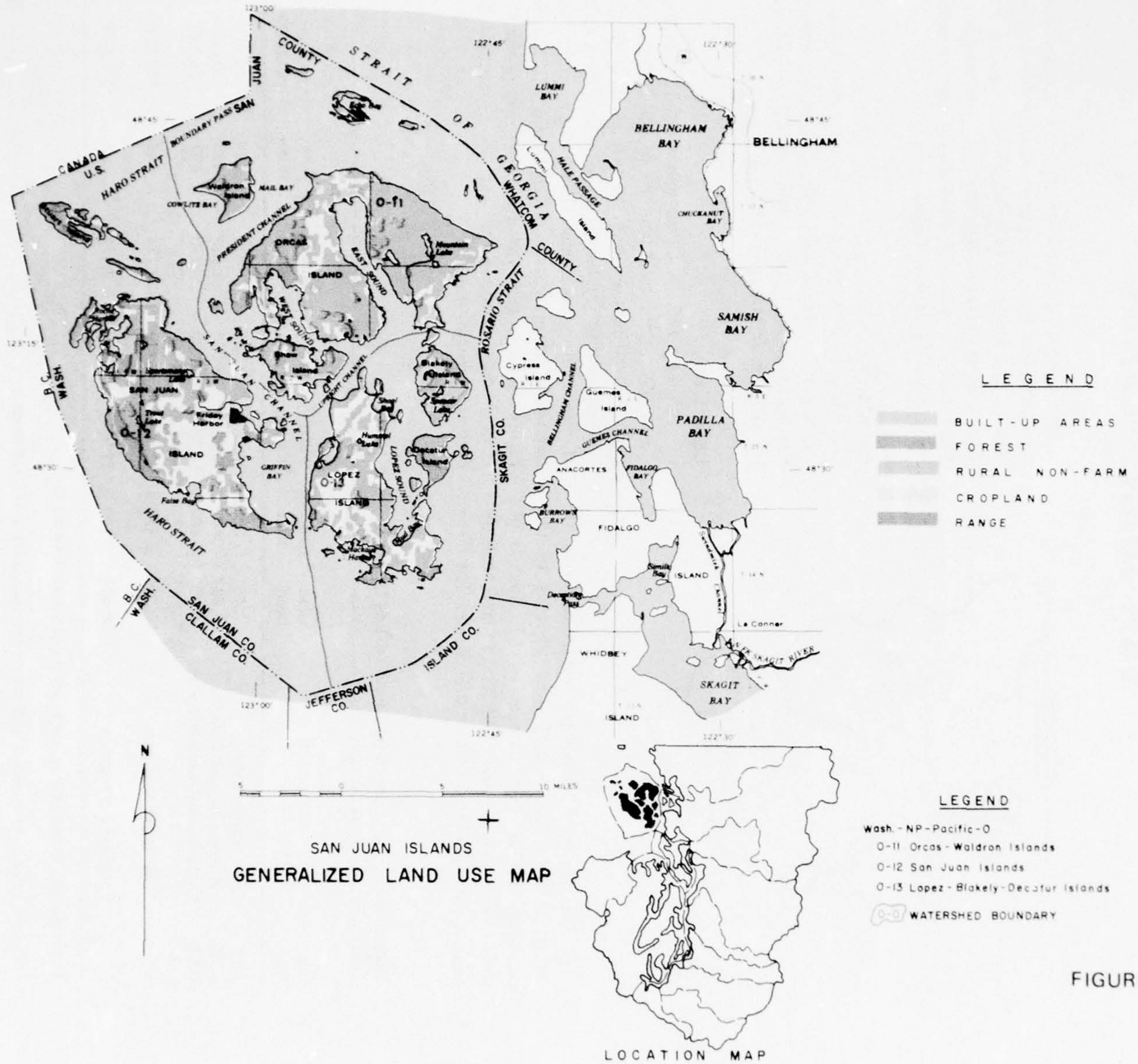
Forests and associated nonforested lands constitute 65% of the total land use for the Islands. The other two major uses of primary interest, croplands and intensive or built-up areas, occupy 17% and 3% of the land, respectively. Table 7-67 shows the tabulation of present land use within the Islands. Figure 7-51, the generalized land use map of the San Juan Islands, portrays the land areas occupied by each of the major uses.

TABLE 7-67. Land use in San Juan Islands (acres)[1]

Map No.	Watershed	Crop-land	Range-land	Total Forest[2]	Rural Non-Agricultural	Built-Up Areas	Fresh Water	Total Area Land and Fresh Water
0-11	Orcas Waldron Islands	3,407	2,295	36,881	3,185	575	484	46,827
0-12	San Juan (Stewart) Islands	8,967	5,042	20,634	3,081	1,379	279	39,382
0-13	Lopez-Blakely-Decatur Islands	6,220	1,792	14,443	2,852	820	192	26,319
	Total Pacific Drainages	18,594	9,129	71,958	9,118	2,774	955	112,528
	Total San Juan Islands	18,594	9,129	71,958	9,118	2,774	955	112,528

[1] Unadjusted measurements, 1966, for Puget Sound Area Study.

[2] Figures include nonforested land commonly associated with forest areas.



STRAIT OF GEORGIA
SAN JUAN COUNTY
WHATCOM COUNTY
SKAGIT CO.
ISLAND CO.
JEFFERSON CO.
SAN JUAN CO.
CLALLAM CO.
CANADA
U.S.
B.C.
WASH.
HARO STRAIT
BOUNDARY PASS
PRESIDENT CHANNEL
SAN JUAN CHANNEL
ROSARIO STRAIT
BELLINGHAM CHANNEL
GUEMES CHANNEL
HALE PASSAGE
EAST SOUND
LOPEZ SOUND
ORCAS
ISLAND
SAN JUAN
ISLAND
LOPEZ
ISLAND
O-11
O-12
O-13
Waldron Island
COWLITZ BAY
MAIL BAY
Friday Harbor
GRIFFIN BAY
False Bay
Cypress Island
Guemes Island
Lummi Island
LUMMI BAY
BELLINGHAM BAY
BELLINGHAM
CHUCKANUT BAY
SAMISH BAY
PADILLA BAY
FIDALGO BAY
ANACORTES
BURROWS BAY
FIDALGO
ISLAND
La Conner
SKAGIT RIVER
SKAGIT BAY
WHIDBEY
ISLAND
123°15'
123°00'
122°45'
122°30'
48°45'
48°30'
N
10 MILES
SAN JUAN ISLANDS
GENERALIZED LAND USE MAP
LEGEND
BUILT-UP AREAS
FOREST
RURAL NON-FARM
CROPLAND
RANGE
LEGEND
Wash.-NP-Pacific-O
O-11 Orcas-Waldron Islands
O-12 San Juan Islands
O-13 Lopez-Blakely-Decatur Islands
WATERSHED BOUNDARY
LOCATION MAP

FIGURE 7-51

AGRICULTURE

PRESENT STATUS AND POTENTIAL

The San Juan Islands study area comprises all of San Juan County. The San Juan Islands lie in the northwestern part of the Puget Sound Study Area.

Of the 473 islands visible at low tide, only six are of major importance. They are: Orcas Island, with an area of 58 square miles, San Juan, 55 square miles, Lopez, 29 square miles, Shaw, 8 square miles, Blakely, 7 square miles, Waldron, 5 square miles, and Decatur, 3 square miles. The rest of the islands grouped together contain about 11 square miles.

All of the land area of 111,573 acres in the San Juan Islands has been mapped by a medium-intensity soil survey. Of the total area mapped, approximately 88,000 acres are classified in Land Use Capability Classes II through VI.

These 88,000 acres are the lands which have the greatest potential for development; i.e., changed use or improvement in use. Land Use Capability Classes II, III, and IV are suited for either cropland or urban uses, and Class VI has potential for urban developments.

The San Juan Islands study area provides the smallest system in the Puget Sound Area. It drains a total area of only 176 square miles. Drainage is accomplished through minor streams that flow directly into Puget Sound. Although the system has only minor streams, it does have a great deal of flood and drainage problem areas which require corrective measures before their potential may be attained. The surface of the Islands is marked by abrupt differences in elevation. Low relief characterizes the glaciated part of the Islands, with glacial plains and gently rolling and basin-like areas. There are 15 mountain peaks on the Islands that exceed 1,000 feet; the highest being Mount Constitution on Orcas Island at 2,409 feet.

Production

Although both forestry and farming have declined in importance, they are still the biggest users of land. Many farming enterprises that were formerly of primary importance have virtually disappeared. Most notable are dairying, poultry, tree fruit, berries, and seed potatoes. Beef has gradually replaced dairy cattle in numbers as the market for cream has declined. Total value of farm production of the San Juan Islands is over $500,000 annually.

Forestry has declined in importance in recent years. The main reasons for the decline of this industry are lower prices offered on the mainland, fewer markets, and a general depletion of local timber resources.

Flooding

Topographic and climatic conditions induce only one flood-producing season annually. It comes in the fall or winter as the result of excessive precipitation. Discharges in excess of channel capacity cause water to spread across the valleys where it remains until the streams drop. In some areas water is trapped by topographic detail until it can seep into the soil.

Drainage

A general discussion of the purposes and problems of establishing drainage is contained in Appendix XIV, Watershed Management. Principles and conditions discussed therein apply to the San Juan Islands Basins and need not be repeated here.

Watersheds

Three watershed areas requiring solutions to problems or development to achieve potential productivity of the Islands are shown on Land Use Map (Figure 7-51) and on the Land Capability Map (Figure 7-52).

Orcas-Waldron Islands watershed (0-11) is the largest watershed in the study area. It contains more than half of all forested lands in the San Juan group. Cropland is less important than forest land and urban built-up areas are almost nonexistent. Potential use would seem to be toward urbanization in the form of resort homes. Forestry and farming should continue to be important for years to come.

San Juan (Stewart) Islands watershed (0-12) and Lopez-Blakely-Decatur Islands watershed (0-13) contain approximately half of all the cropland and urbanized areas in the Islands. The Islands have potential for the building of resort homes and a potential for increased agricultural production.

Many of the farm lands mentioned above have common problems of flooding and a need for soil profile drainage. Proposed solutions for these condi-

tions are summarized in the Puget Sound Area section of this Appendix under "Means to Satisfy Needs," and are discussed in more detail in Appendix XIV, Watershed Management.

Tables

Generalized land use in the San Juan Islands is shown in Table 7-67. The following tables are to indicate the potential development possible within acceptable land use standards.

Table 7-68 shows the relative importance of groups of crops within the farming sector of agriculture at the basin level. Data from the 1964 Census of Agriculture were expanded to agree with measured acreages for this table.

Table 7-69 shows the number of acres in each capability class, subclass, and unit, by watersheds, in the San Juan Islands. This table can be used with the description of capability units to estimate the potential for development.

TABLE 7-68. Distribution and value of production by crops in San Juan Islands

Land Use	Cropland This Use (Census)[1] (acres)	Cropland This Use (Expanded) (acres)	Percent This Use (percent)	Value of Production (dollars)	Percent of Value This Use (percent)
Small grains	467	652	3.51	31,452	4.81
Field crops	--	--	--	--	--
Vegetables	495	691	3.72	148,278	22.69
Berries	--	--	--	--	--
Nursery products	--	--	--	--	--
Cropland not used	1,572	2,195	11.80	--	--
Sub-Total	2,534	3,538	19.03	179,730	27.50
Hay	3,058	4,270	22.97	200,145	30.62
Hay aftermath	--	--	--	--	--
Sub-Total	3,058	4,270	22.97	200,145	30.62
Silage (grass)	130	182	.98	12,054	1.85
Grass aftermath	--	--	--	--	--
Sub-Total	130	182	.98	12,054	1.85
Silage (corn) fodder	10	14	.07	1,587	.24
Pasture (cropland)	7,583	10,590	56.95	260,090	39.79
Sub-Total	10,781	15,056	80.97	473,876	72.50
Total	13,315	18,594	100.00	653,606	100.00

[1] Figures by counties from 1964 Census of Agriculture were disaggregated to Basins on basis of 1966 measured acreages.

SAN JUAN ISLANDS
GENERALIZED
LAND CAPABILITY MAP
Class and Subclass

LEGEND

LAND SUITED FOR CULTIVATION AND OTHER USES

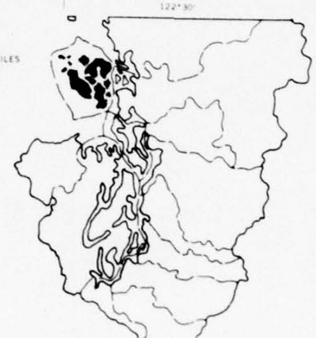
I	Soils in Class I have few limitations that restrict their use. They are well suited for cultivated crops, pasture, woodland, wildlife, and recreation.
II	Soils in Class II have some limitations that reduce the choice of plants, or require moderate conservation practices. The soils are well suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
III	Soils in Class III have severe limitations that reduce the choice of plants, or require special conservation practices. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. The soils are suited for cultivated crops, pasture, woodland, wildlife food and cover, and recreation.
IV	Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. The soils in Class IV may be used for crops, pasture, woodland, wildlife food and cover, and recreation.

LAND LIMITED IN USE
GENERALLY NOT SUITED FOR CULTIVATION

V	Soils in Class V have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover.
VI	Soils in Class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, wildlife food and cover, and recreation.
	Soils in Class VII have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland, wildlife, recreation, and water supply.
VIII	Soils and land forms in Class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

PRIMARY SUBCLASSES

e-Potential erosion or past erosion damage, sediment source.
w-Wetness, poor drainage or overflow.
s-Shallowness, stoniness or low moisture-holding capacity, etc.



LOCATION MAP

LEGEND

Wash. - NP - Pacific - O
O-11 Orcas - Waldron Islands
O-12 San Juan Islands
O-13 Lopez - Blakely - Decatur Islands
WATERSHED BOUNDARY

FIGURE 7-52

TABLE 7-69. Land capability units in San Juan Islands (acres)[1]

Capability Units[2]	WATERSHEDS 0-11	0-12	0-13	Total
II ws 06	278	734	272	1,284
II Total	278	734	272	1,284
III ew 01	110	1,097	569	1,776
III we 16	2,411	1,053	1,131	4,595
III ws 04		395		395
III ws 09	290	318	67	675
III ws 10	1,451	4,094	1,668	7,213
III ws 11	196	378	1,962	2,536
III sw 04	35	10	205	250
III sw 09	2,210	2,653	3,364	8,227
III Total	6,703	9,998	8,966	25,667
IV ew 12	928	1,097	115	2,140
IV ew 22	1,700	2,647	1,187	5,534
IV es 11		20		20
IV ws 06	55	76	258	389
IV ws 11	944	377	615	1,936
IV se 05	551	406	45	1,002
IV sw 09	99	2,485	1,286	3,870
IV Total	4,277	7,108	3,506	14,891
II-IV Total	11,258	17,840	12,744	41,842

[1] Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

[2] See Exhibit 1 for description of capability units.

TABLE 7-69. Land capability units in San Juan Islands (acres)[1] (cont.)

Capability Units[2]	WATERSHEDS 0-11	0-12	0-13	Total
VI ew 21	1,337	1,143	1,255	3,735
VI ew 28	697	1,358	665	2,720
VI es 17		238	10	248
VI es 25	9,313	318	737	10,368
VI es 27	9,371	9,250	3,638	22,259
VI ws 02	19		20	79
VI so 10	30		5	35
VI so 18	2,356	429	1,168	3,953
VI so 21		561	200	761
VI se 17	30	102	872	1,274
VI se 21		728	65	793
VI Total	23,423	14,167	8,635	46,225
VII es 29	42	157	45	244
VII es 35	8,869	63	2,095	11,027
VII es 36	2,405	6,497	1,983	10,885
VII Total	11,316	6,717	4,123	22,156
VIII ew 39	340	259	414	1,013
VIII es 38		90	26	116
VIII ws 23	1	25	140	166
VIII ws 24	5	5	45	55
VIII Total	346	379	625	1,350
VI-VIII Total	35,085	21,263	13,383	69,731
II-VIII Total	46,343	39,103	26,127	111,573

1 Unadjusted measurements, 1966, for Puget Sound Area Study, based on National Cooperative Soil Survey maps.

2 See Exhibit 1 for description of capability units.

PRESENT AND FUTURE NEEDS

Urban Needs

Population in the San Juan Islands will increase from 2,600 persons in 1967 to approximately 5,100 persons by 2020, according to Regional Economic Studies Technical Committee data. At a density of six persons per acre, the 11,892 acres presently in intensive and rural nonagricultural use will provide ample acreage for new intensive development to the year 2020 without encroachment on the cropland of the Islands.

Cropland Needs

The Islands presently have 18,594 acres of cropland. It is expected that cropland will increase slightly in each of the three time periods, reaching a level of 22,000 acres by 2020. Percent increases needed, by crops, for the Puget Sound Area are shown in Table 2-15.

Protection and Development Needs

Data in Table 7-70 shows the number of acres of cropland that will need protection and development, by time periods, to meet future production requirements under sustained use.

MEANS TO SATISFY NEEDS

The program of management and development for sustained use is the means by which agricultural resource needs are met. Structural measures are of a project type. Many Federal, State, and local entities of government participate with the private sector in developing resources.

The program of the United States Department of Agriculture for the San Juan Islands is summarized under the topic "Program Implementation" immediately following Forestry. A more complete description is found in Appendix XIV, Watershed Management.

TABLE 7-70. Protection and development needs

Measures Needed	Unit	1980	2000	2020
Floodwater protection[1]	acre	17,294	17,294	17,294
Watershed protection and rehabilitation[2]	acre	29,129	30,129	31,129
Drainage improvement	acre	9,856	16,427	21,903
Irrigation development[3]	acre	500	1,000	4,000
Water for irrigation[4]	ac.ft.	1,000	2,000	8,000

1 A total of 17,294 acres in the San Juan Islands are subject to flooding.

2 Includes 9,129 acres of rangeland.

3 According to Appendix VII, Irrigation, there were 100 acres (using 200 acre-feet of water) irrigated in 1966. The Irrigation Appendix projects this figure to remain constant through 2020.

4 Based on gross diversion requirements of 2.0 acre-feet per acre, estimated by Irrigation Committee in Appendix VII, Irrigation.

FORESTS

PRESENT STATUS

The San Juan Islands contain 77,560* acres of forest land which is some 61% of the hydrologic area (Table 7-71). Forests are present on all the islands of the group. 8,130 acres of forest land is officially designated as reserved, primarily in the Moran State Park and in refuges administered by the Fish and Wildlife Service. The nonreserved forest land is classified by zones as follows:

Zone	Area (acres)	Percent of Total
Woodland and Woodlot	69,150	100
Principal Forest	280	0
Upper Forest	--	--
Subalpine	--	--
Total forested land	69,430	100

*Does not include nonforested lands commonly associated with forest areas.

The San Juan Islands are not classified into commercial and noncommercial forest land under the standards for the Puget Sound and Adjacent Waters

TABLE 3-46. San Juan Islands—Area of forest land, in acres, by ownership and type

Cover Type or Land Class	Available: Other Federal	Available: Private	Available: Total Available	Unavailable	Total Available & Unavailable
Douglas-fir, seedlings and saplings	20	5,530	5,550	90	5,640
Douglas-fir, poletimber	70	24,930	25,000	190	25,190
Douglas-fir, small young growth sawtimber	60	19,390	19,450	4,180	23,630
Douglas-fir, old growth and large young growth sawtimber	10	5,540	5,550	2,770	8,320
White fir, small sawtimber	10	2,770	2,780	170	2,950
White fir, large sawtimber	10	2,780	2,790	--	2,790
SUBTOTAL, softwoods	180	60,940	61,120	7,400	68,520
Hardwoods, seedlings and saplings	10	2,650	2,660	30	2,690
Hardwoods, poletimber	10	2,880	2,890	170	3,060
Hardwoods, small sawtimber	--	2,760	2,760	530	3,290
SUBTOTAL, hardwoods	20	8,290	8,310	730	9,040
TOTAL, all forested land	200	69,230	69,430	8,130	77,560

Study. The forest land area of 69,430 acres supports a sawtimber volume of about 156 million board feet, International ¼-inch Rule (Table 7-72). These figures represent less than 1% of Puget Sound Area's commercial timber area and an insignificant amount of its timber volume. Within this classification, there are 69,230 acres of privately-owned forest land with only 200 acres in public ownership. All of the privately-owned forest land, except for 80 acres of corporate land, is in small holdings. As indicated in the zoning classification above, all of the privately held forest land is in woodland and woodlots.

The forest lands of the San Juan Islands do not present any significant opportunity for the development of forest products industries. There are only two mills in the area. These are sawmills located at Friday Harbor with a total daily output of 17,000 board feet.

The San Juan Islands are fast becoming a recreation and residence area. Forest land management is more concerned with natural beauty and fire protection than with production of timber products. Zoning programs are all pointed toward pastoral living conditions rather than encouraging industrial development.

PRESENT AND FUTURE NEEDS AND MEANS TO SATISFY NEEDS

Future development of the forest products industries and management of forest lands for timber production are expected to be very limited in the San Juan Islands. These lands have a high potential for recreation development and, in addition, are highly attractive for the private development of summer homes, resorts, or similar forms of land use. The current ownership pattern, as well as expected changes in ownership, suggests that timber production will not be practiced on any significant scale. It is, therefore, assumed that the forest area of the San Juan Islands will be wholly removed from commercial timber production by the year 2020.

The conversion or reservation of forest land for other purposes will not occur overnight, however. In the interim, some timber will be marketed from sporadic cutting of the predominantly second-growth stands and as a result of land clearing operations. The volume is expected to be small, however, due to the pattern of small ownerships and small size of the timber involved.

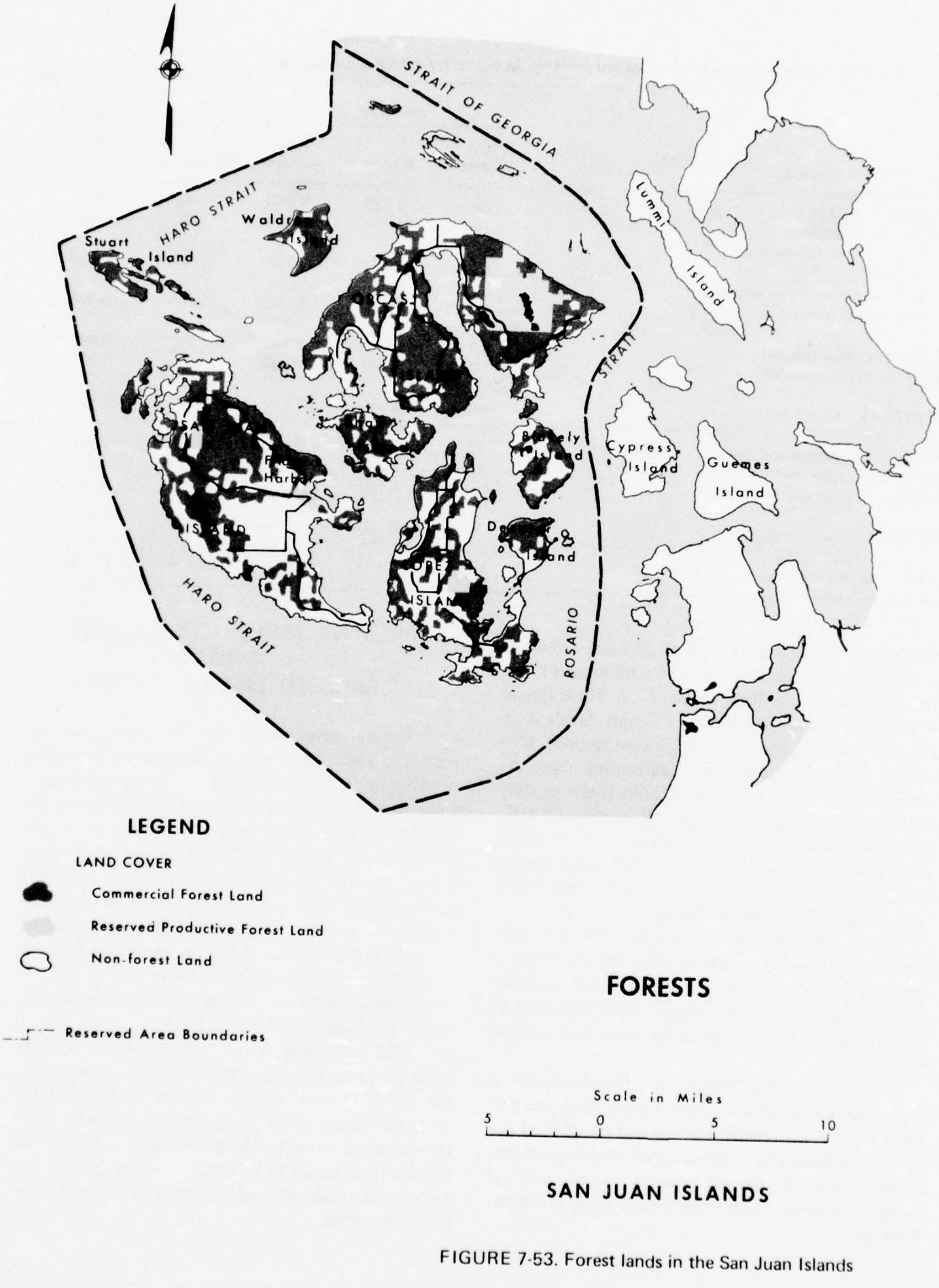


FIGURE 7-53. Forest lands in the San Juan Islands

TABLE 3-47. San Juan Islands—Volume of sawtimber and growing stock, by ownership, on productive forest land

Species or Group	Available			Unavailable	Total Available & Unavailable
	Other Federal	Private	Total Available		
Sawtimber—Thousand board feet, International ¼-inch Rule					
Douglas-fir, small sawtimber	960	307,010	307,970	48,360	356,330
Douglas-fir, large sawtimber	580	319,950	320,530	99,350	419,880
Other softwood species, small sawtimber	110	28,110	28,220	1,870	30,090
Other softwood species, large sawtimber	560	90,050	90,610	--	90,610
SUBTOTAL, softwoods	2,210	745,120	747,330	149,580	896,910
Hardwoods, small sawtimber	10	30,500	30,510	6,030	36,540
Hardwoods, large sawtimber	10	3,580	3,590	210	3,800
SUBTOTAL, hardwoods	20	34,080	34,100	6,240	40,340
TOTAL sawtimber, all species	2,230	779,200	781,430	155,820	937,250
Growing Stock—Million cubic feet					
Douglas-fir	0.2	114.2	114.4	26.9	141.3
Other softwood species	0.3	46.8	47.1	0.7	47.8
SUBTOTAL, softwoods	0.5	161.0	161.5	27.6	189.1
Hardwoods	0.0	13.5	13.5	2.5	16.0
TOTAL GROWING STOCK, all species	0.5	174.5	175.0	30.1	205.1

Current and projected commercial forest area in the San Juan Islands 1965-2020 (in thousand acres)

Period	Ownership					Total
	Private			Public		
	Large	Medium	Small	Federal	Other	
1965	0.1	--	69.1	--	0.2	69.4
1980	--	--	17.3	--	--	17.3
2000	--	--	--	--	--	--
2020	--	--	--	--	--	--

Since commercial timber cutting is expected to be limited, there will be little need for the watershed protection measures suggested for such operations. The expected land use pattern will emphasize aesthetic appearance, therefore, it is assumed that the land owners will perform any needed erosion control on other work that will be necessary in maintaining these values.

PROGRAM IMPLEMENTATION

AGRICULTURE AND FORESTS

In order to sufficiently provide for the needs of the San Juan Islands, as set forth in the preceding pages, the following plan has resulted. It is multipurpose in nature and will provide for floodwater

damage prevention, watershed protection, and rehabilitation, drainage improvement, and irrigation development. Other measures provide for water quality and quantity control, recreation, and fish and wildlife development.

This plan includes programs and projects designed to accomplish specific objectives of conservation and development, and also provides for the full development of lands presently used for farming. It is planned that such lands continue in their present use with an additional 3,400 acres being diverted to cropland by 2020.

The plan is broken down into three time periods: (a) early action (within the next ten years); (b) near future (1980-2000); and (c) distant future (2000-2020).

Program measures are on-site practices which take advantage of developments made possible by the structural works of improvement, as well as measures for watershed protection, conservation treatment, and water management. These measures will include seeding of improved grasses and legumes, cover crops, drainage development, forest management, and irrigation development. Total cost of the program for the early action period is $6,546,000. No projects are scheduled for this time period.

Three projects, covering the entire area, with an installation cost of $2,736,000 are scheduled for the period between 1980 and 2000. No additional projects are planned. Program costs are expected to be $8,889,000 in the 1980-2000 period and $8,118,000 in the 2000-2020 time period. Total cost of the plan is expected to be $26,289,000.

A presentation of the proposed plan, including agriculture, may be found in Appendix XIV, Watershed Management, San Juan Islands section.

MINERALS

By far the most important mineral produced in the San Juan Islands is limestone. Other mineral products that have been produced are sandstone and sand and gravel. Peat also occurs in the area.

The locations of the known mineral deposits in the Islands are shown on Figure 7-54. The open circles on the maps indicate properties that have a record of production; the dots with numbers represent properties for which estimates of ore reserves have been made. These properties also are tabulated on the pages facing the maps and are identified by numbers which are used in the text where references are made to given properties.

Limestone

Limestone occurs on several islands of the San Juan group as pods, lenses, and beds in argillite of mostly Paleozoic age (a few small deposits are Mesozoic in age).

Most of the limestone mined has been used to make lime. First production of limestone was started about 1882 and has been practically continuous since that date. An estimated 9 million tons of limestone has been produced from the area. Reserves are estimated at over 1.5 million tons. A breakdown of deposits shows 1 deposit that contains more than 1 million tons, 6 deposits each with between 10,000 and 1 million tons, and 34 deposits each having less than 10,000 tons or whose size is not known.

Sandstone

Four quarries have a record of sandstone production. The amount of production and reserves are not known. The sandstone was used for building stone, paving blocks, and riprap.

Sand and Gravel

Ten sand and gravel pits are listed for the San Juan Islands, and at present (1966), one pit is producing material commercially. No estimate of reserves is available; however, they are probably small.

Clay

One clay deposit has a record of production, but it no longer is used.

Peat

Thirteen peat bogs totaling 498 acres have been examined in detail. Eight of these contain sphagnum peat. No peat production from the area has been recorded.

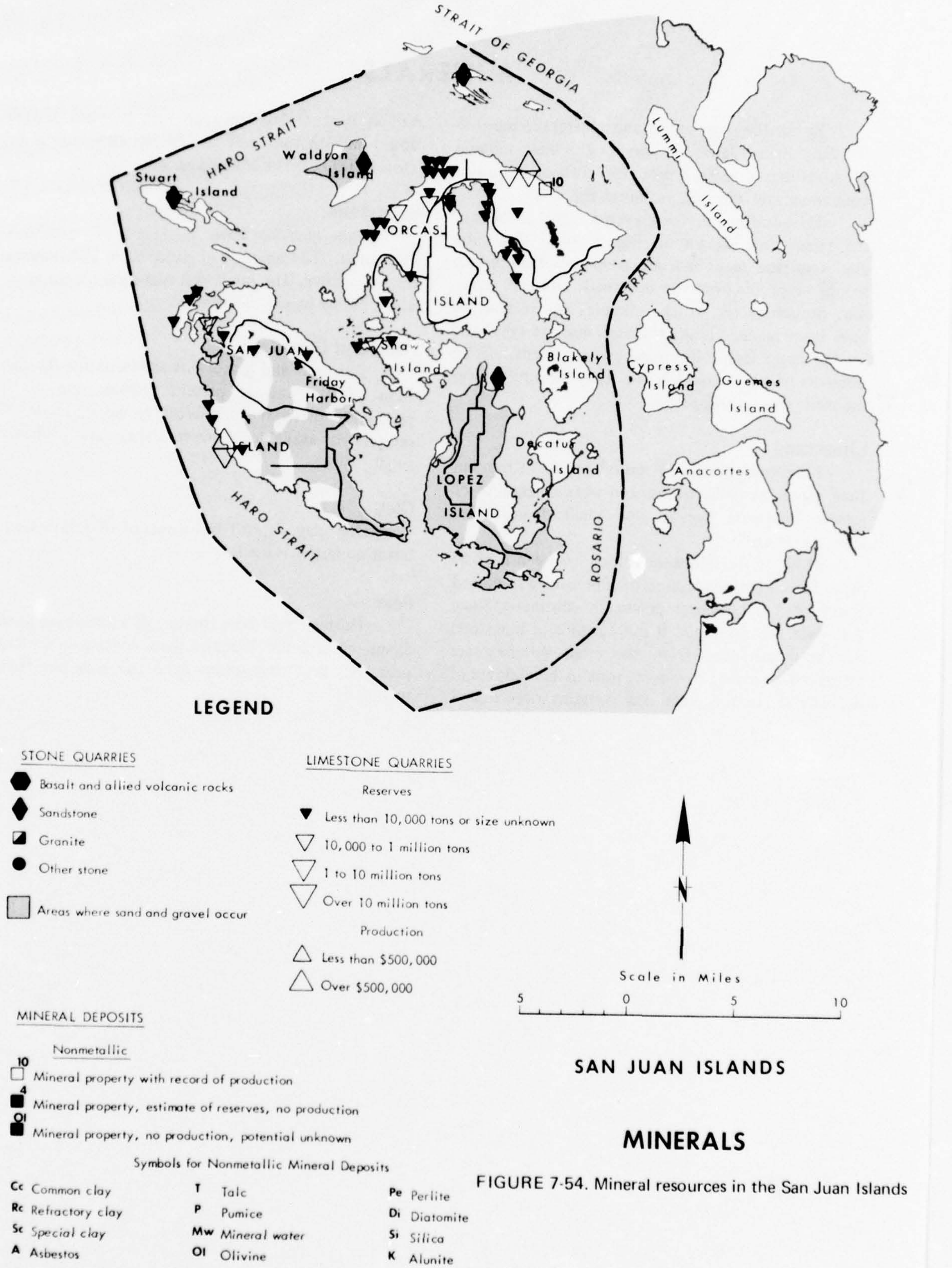


FIGURE 7-54. Mineral resources in the San Juan Islands

MINERAL PROPERTIES IN SAN JUAN ISLANDS

Explanation for Figure 7-54

Nonmetallic Minerals

Common clay (1 property)
10 – Orcas Island

Stone Deposits

Limestone

Reserves
Less than 10,000 tons (34 properties)
10,000 to 1 million tons (6 properties)
More than 1 million tons (1 property)

Sandstone (4 properties)

INTENSIVE LAND USE

The San Juan Islands are a group including some 170 islands off the northwest coast of the mainland of Washington. The San Juan Islands, making up San Juan County, are surrounded by deep waters, with numerous protected bays and harbors; Haro Strait on the west, Rosario Strait on the east, the Strait of Georgia on the north, and the Strait of Juan de Fuca on the south.

The San Juan Islands are predominantly in private ownership. In 1940, 34 percent of the county work force was in agriculture, but by 1960 the percentage had dropped to seven. Subdividing farms, especially waterfront and view property, for rural residences, has replaced farming itself. There is only one incorporated town and approximately 18 unincorporated places.

Friday Harbor

The city of Friday Harbor was incorporated as early as 1909, but in 1967 had a population of only 784. It is the largest town in the San Juans as well as the county seat. Major activities center around tourism, the University of Washington Oceanography Laboratory and the fishery industry.

Unincorporated places include Waldron, Roche Harbor, Argyle, Richardson, Otis, Decatur, Lopez, Port Stanley, Shaw, Orcas, Deer Harbor, West Sound, Eastsound, Rosario, Olga, Doebay and Thatcher.

TRANSPORTATION

Highways–Roadways are more or less limited to county roads on the major islands.

Airways–Airports are available on most of the major islands for use of commercial or private aircraft. Regular air service is available at Friday Harbor.

Navigation–Port facilities are pretty much limited to ferry terminals and small boat piers. Ferries from Anacortes make regular trips through the islands, carrying vehicles and passengers.

LAND USE CHARACTERISTICS

There are 112,528 acres of land in the San Juan Islands. Table 7-67 contains the figures showing the various amounts of major land use acreages within the Islands.

Figure 7-51 shows the land use pattern for the San Juan Islands. It is easy to see that there is presently only a small part of these islands being put to an intensive use.

Intensive Land Use

At the present time (1967) intensive land uses occupy some 2,774 acres or 2.5 percent of the Islands' land area. Most of the intensive land uses are

located in or near Friday Harbor although intensive uses are scattered throughout the Islands as are the eighteen unincorporated places. The following list contains the land use figures for the intensive land use subgroups.

Railroads	Roadways	Airports	Urban (Built-up)	Total
10	838	639	1,287	2,774

Rural Nonagricultural

Many of the land uses classified within the rural nonagricultural category are similar in character and often associated with or the forerunners of intensive land use. The following list contains the acreages of the several subgroups in the rural nonagricultural category.

Rural Nonfarm Residences	River Wash Tidelands	Mines	Farmsteads (farm yards)	Total
6,558	730	1,830	0	9,118

Land Ownership

Of the total land area (111,573 acres) in the San Juan Islands, 80.4 percent is in private ownership, 8.6 percent in private corporate ownership, 3.5 percent in Federal ownership, 5.9 percent in State ownership and 1.6 percent in local government ownership. The bulk of the private corporate, Federal and State ownerships are forested areas. Land area owned by local government is mainly in and around Friday Harbor and consits of streets, facilities, local parks and similar areas. Other private (nonforest) ownerships are primarily rural nonagricultural and agricultural land areas.

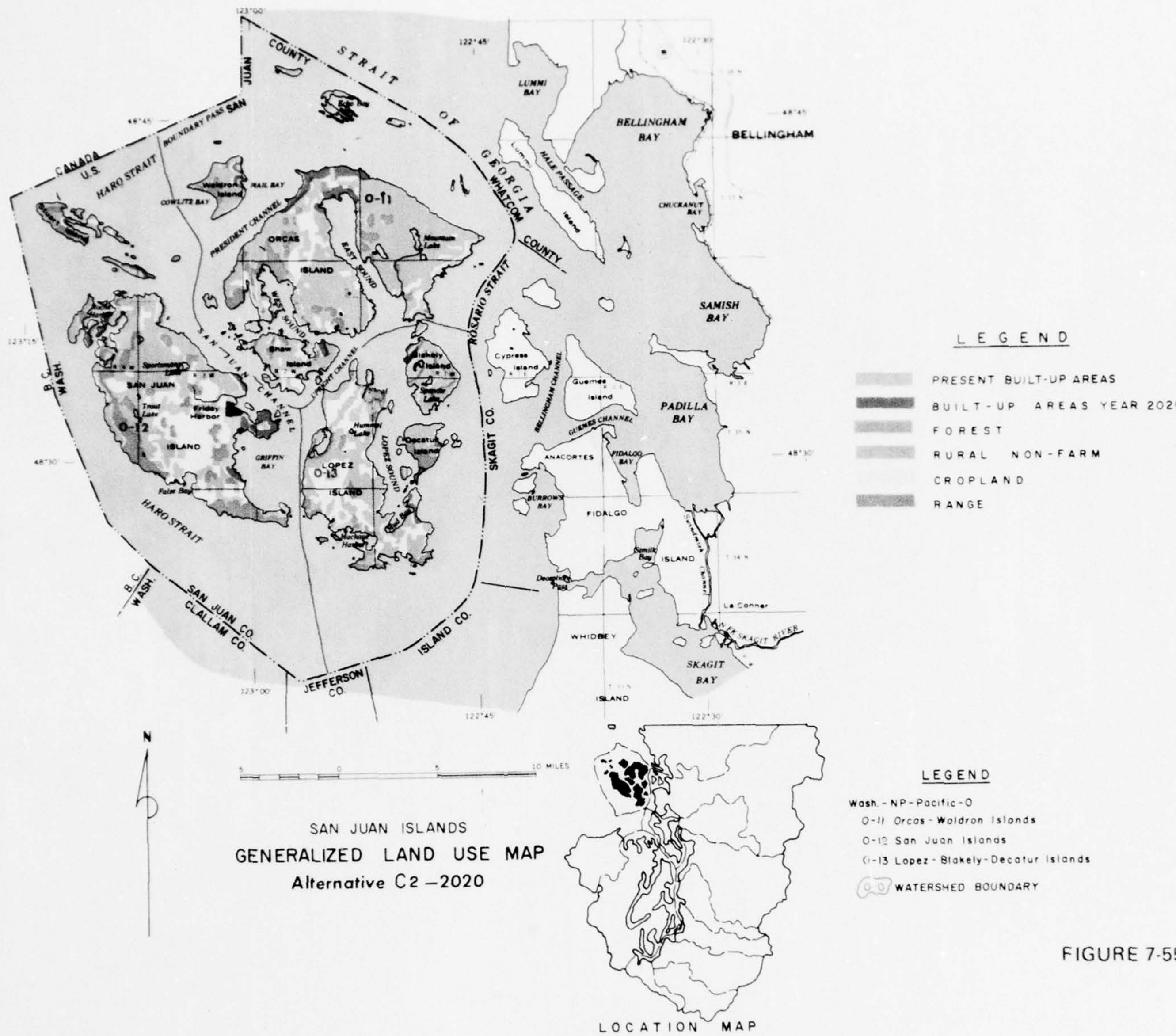
TRENDS AND POTENTIALS

Intensive land use in the San Juan Islands amounts to some 3,000 acres or approximately one-eighth of a township. This area accounts for one percent of the total Islands' area. The small amount of intensive land use presently required is being filled in and around the city of Friday Harbor and in various scattered locations. There are no major areas in the San Juan Islands considered likely for intensive development. Scattered and minor intensive land uses will likely continue to occur throughout the Islands, mainly of a full time and part time residential nature, particularly as pressures for retirement and vacation homes increase over time.

PRESENT AND FUTURE NEEDS

An examination of the Islands shows that they are being subdivided into summer home and recreation lots. This trend will continue for a number of years, with the outer perimeter of the Islands being subdivided first. Present population (1967) is 2,600, and this will increase to only 5,100 by the year 2020. Density projections call for only 1.4 persons per acre, thus by the year 2020, there will be a need for only 3,600 acres of land being put to intensive uses and this will generally be on a scattered basis. Figure 7-55 portrays the projected future land use pattern (C_2) for the San Juan Islands for the year 2020.

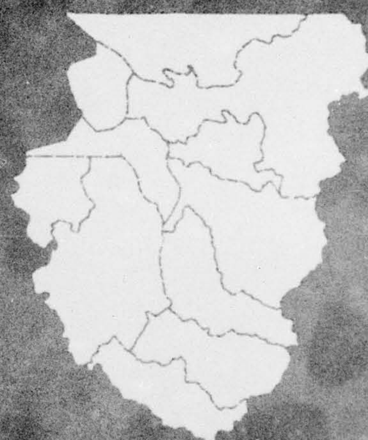
There is little need for industrial land within the Islands in future years. Recreation lands are the critical need. Efforts should be made to put large acreages of lands into public ownership to assure ample recreation land for future generations. Recreation should be considered the "prime industry" of the Islands at this time and in the years to come.



SAN JUAN ISLANDS
GENERALIZED LAND USE MAP
Alternative C2 – 2020

FIGURE 7-55

Part Eight
Glossary of Terms



PART EIGHT—GLOSSARY OF TERMS

ACID SOIL—A soil giving an acid reaction (precisely, below pH 7.0; practically, below pH 6.6) throughout most or all of the portion occupied by roots.

ACIDIC ROCK—Composed of over 52 percent silica.

ACRE-FOOT (ac-ft)—A unit commonly used for measuring the volume of water or sediment; equal to the quantity of water required to cover one acre to a depth of one foot and equal to 43,560 cubic feet or 325,851 gallons.

ADOPTED LOW WATER—The datum for measuring the depth of navigation channels in free flowing rivers. It is the level of the water surface at the minimum flow which has occurred for a continuous period of 15 days.

ALKALINE SOIL—A soil with so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is reduced.

ALLUVIUM—Soil material, such as rocks, gravel, sand, silt, or clay, that has been deposited by water.

ANIMAL UNIT MONTH—The amount of food or forage required by an animal unit for one month. An animal is one mature cow with calf under six months of age or equivalent. Animal unit equivalent varies by agencies for horse, sheep, goats, or wildlife.

AQUIFER—A rock formation, bed, or zone containing water that is available to wells. An aquifer may be referred to as a water-bearing formation or water-bearing bed.

ARTESIAN WATER—Ground water under sufficient pressure to rise above the level at which the water-bearing bed is reached in a well. The pressure in such an aquifer commonly is called artesian pressure, and the rock containing artesian water is an artesian aquifer.

AVAILABLE WATER HOLDING CAPACITY—The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

BASE RUNOFF—Sustained or fair weather runoff. In most streams, base runoff is composed largely of ground water effluent. The term base flow is often used in the same sense as base runoff. However, the distinction is the same as that between streamflow and runoff. When the concept in the terms base flow and base runoff is that of the natural flow in a stream, base runoff is the logical term.

BASIC PLANNING STUDIES—Those studies dealing with the physical, political, social and economic characteristics (present and future) of an area.

BASIC ROCK—Composed of less than 52 percent silica.

BASIN—A concave area in which the strata slopes toward the center.

BOTTOM LAND—Low land formed by alluvial deposits along a river or stream.

CALCAREOUS SOIL—Soil containing sufficient calcium carbonate (often with magnesium carbonate) to effervesce visibly to the naked eye when treated with hydrochloric acid. Soil alkaline in reaction, owing to the presence of free calcium carbonate; may be more or less cemented, depending upon concentration and time.

CAPITAL EXPENDITURES—Outlays for plant and equipment which are normally charged to fixed asset accounts.

CHANNEL STORAGE—The volume of water at a given time in the channel or over the flood plain of the streams in a drainage basin or river reach. Channel storage is sometimes significant during the progress of a flood event.

CLAY—As a soil separate, mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

CLAYPAN—A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

COAL—Lignite, subbituminous, bituminous, and anthracite unless specifically designated as one or the other.

COLLUVIUM—Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

COMMUNITIES—An area with some degree of homogeneity—physical, political, social or economic—from which it obtains an identity.

CONE OF DEPRESSION—A cone-like depression of the water table or other piezometric surface that is formed in the vicinity of a well by withdrawal of water. The surface area included in the cone is known as the area of influence of the well.

CONFINED WATER (ARTESIAN)—Water under artesian pressure. Water that is not confined is said to be under water table conditions.

CONSUMPTIVE USE—The quantity of water discharged to the atmosphere or incorporated in the products in the process of vegetative growth, food processing, industrial processes, or other use. Hence, the amount of water no longer directly available.

CONSUMPTIVE USE REQUIREMENT (CROP)—The annual irrigation consumptive use expressed in feet or acre-feet per acre.

CONSUMPTIVE WASTE—The water that returns to the atmosphere without benefiting man.

CORRELATION—The process of establishing a relation between two or more related variables. It is a simple correlation if there is only one independent variable; multiple correlation if there is more than one independent variable.

CROPLAND—Land regularly used for production of crops, except forest land and rangeland.

CROPLAND, IDLE—This includes the land classified as cropland because of prior use but not currently cropped.

CROPLAND, IRRIGATED—Land to which water is usually applied by controlled artificial means.

CUBIC FEET PER SECOND (cfs)—A unit expressing rate of discharge. One cubic foot per second is equal to the discharge of a stream having a cross section of one square foot and flowing at an average velocity of one foot per second. It also equals a rate of 448.8 gallons per minute.

DEEP DRAFT—Commercial vessels with drafts of 18 feet or greater.

DENSITY—The quantity of anything per unit of volume or area.

DENSITY STANDARDS—The goals of what the community wants to achieve; i.e., the number of persons per unit of land.

DEPLETION (WATER)—That portion of water supply that is consumptively used.

DEPLETION, STREAMFLOW—The amount of water that flows into a valley, or onto a particular land area, minus the water that flows out of the valley or off from the particular land area.

DIAMETER BREAST HIGH (d.b.h.)—Diameter of the tree, including the bark, at 4.5 feet above the average ground level.

DISPLACEMENT—The weight in long tons (2240 lbs.) of a ship and all its contents. The size of naval and passenger vessels is usually expressed as "tons displacement."

DIVERSION—The taking of water from a stream or other body of water into a canal, pipe, or other conduit.

DRAINAGE AREA—The drainage area of a stream, measured in a horizontal plane, which is enclosed by a drainage divide.

DRAINAGE BASIN—A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

DRAINAGE CLASS—The relative terms used to describe natural drainage are explained as follows:

Excessive—Excessively drained soils are commonly very porous and rapidly permeable, and have low water-holding capacity.

Somewhat Excessive—Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Good—Well drained soils that are nearly free of mottling and are commonly of intermediate texture.

Moderately Good—Moderately well drained soils that commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the surface layers and upper subsoil, and mottling in the lower subsoils and substrata.

Somewhat Poor—Somewhat poorly drained soils are wet for significant periods, but not all the time. They commonly have a slowly permeable layer in the profile, a high water table, additions through seepage, or a combination of these conditions.

Poor—Poorly drained soils are wet for long periods of time. They are light gray and generally are mottled from the surface downward, although mottling may be absent or nearly so in some soils.

DRAINAGE DIVIDE—The line of highest elevations which separates adjoining drainage basins.

DRAWDOWN (GROUND WATER)—The depression or decline of the water level in a pumped well or in nearby wells caused by pumping. It is the vertical distance between the static and the pumping level at the well.

DUFF—A type of organic surface horizon of forested soils consisting of matted peaty organic matter only slightly decomposed.

ECONOMIC BASE STUDY—A study which evaluates the economic structure of the region to provide economic projections necessary for the appraisal of future water resource needs.

EVAPOTRANSPIRATION—Water dissipated from a land area by evaporation from water surfaces and moist soil, and by plant transpiration.

FARM—A place operated as a unit of ten or more acres from which the sale of agricultural products totaled $50 or more annually, or a place operated as a unit of less than ten acres from which the sale of agricultural products totaled $250 or more annually during the previous year.

FEDERAL LANDS—All classes of land owned by the Federal Government, which includes both public domain land and acquired Federal land.

FEDERAL LANDS, ACQUIRED—Land acquired by the Federal Government through purchase, condemnation, or gift.

FEDERAL LANDS, WITHDRAWN—Federal lands for which formal withdrawal action has been taken which restricts the disposition of specific public lands and which holds them for specific public purposes; also, public lands which have been dedicated to public purposes.

FLOOD—Any relatively high streamflow or an overflow or inundation that comes from a river or other body of water and causes or threatens damage.

FLOOD FREQUENCY CURVE—A graph showing the number of times per 100 years, or the average interval of times within which a flood of a given magnitude will be equaled or exceeded.

FLOOD PEAK—The highest value of the stage or discharge attained by a flood; thus, peak stage or peak discharge. Flood crest has nearly the same meaning, but since it connotes the top of the flood wave, it is properly used only in referring to stage.

FLOOD PLAIN—A strip of relatively smooth land bordering a stream that has been or is subject to flooding. It is called a "living" flood plain if it is overflowed in times of high water, but a "fossil" flood plain if it is beyond the reach of the highest flood.

FLOOD, PROBABLE MAXIMUM—The largest flood for which there is any reasonable expectancy in the geographical region involved.

FLOOD ROUTING—The process of determining progressively downstream the timing and stage of a flood at successive points along a river.

FLOOD STAGE—The stage at which overflow of the natural banks of a stream begins to cause damage in the reach in which the stage is observed.

FLOWING WELL—An artesian well having sufficient head to discharge water above the land surface.

FOREST LAND—Land which is at least 10 percent stocked by forest trees of any size and land from which the trees have been removed to less than 10 percent stocking but which has not been developed for other use.

FOREST LAND, COMMERCIAL—Forest land which is producing, or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation.

FOREST LAND, NONCOMMERCIAL—Unproductive forest land incapable of yielding crops of industrial wood because of adverse site conditions, and productive forest land withdrawn from commercial timber use through statute or administrative regulation.

FOREST LAND, NONSTOCKED—Commercial forest land less than 10 percent stocked with growing stock trees.

FOREST LAND, PRODUCTIVE–RESERVED—Public forest land withdrawn from timber utilization through statute, ordinance, or administrative order, but which otherwise qualifies as commercial forest land. Examples include the National Parks and National Forest Primitive and Wilderness areas.

FOREST LAND, UNPRODUCTIVE—Forest land incapable of yielding crops of industrial wood products (usually saw timber) because of adverse site conditions.

FOREST RANGE—Forest land available for the grazing of domestic livestock and wildlife. It may be either commercial or noncommercial forest land.

FRAIL LANDS—Lands characterized by either a thin or unstable topsoil, or in some instances no topsoil whatsoever. Subsoils are normally clays, fine silts, or sands. Frail lands are ordinarily those on which the plant cover is sparse or easily injured, leading to increased runoff or erosion. Many of these areas are geologic parent materials that do not have sufficient soil development to produce a vegetative cover that would stabilize normal geologic erosion. Some of these areas may consist of barren rock or shale deposits.

GAGING STATION—A particular site on a stream, canal, lake or reservoir where systematic observations of gage height or discharge are obtained.

GOAL—A general aim or desired end; a broad, long-range purpose toward which policy, decisions and actions are directed.

GROSS TON—The interior measurement of a ship in units of 100 cubic feet. The size of general cargo vessels is usually expressed in terms of gross tons.

GROUND WATER—Water in the ground that is in the zone of saturation from which wells, springs and ground water runoff are supplied.

GULLY EROSION—The widening, deepening, and headcutting of small channels and waterways due to erosion.

HARDPAN—A hardened or cemented soil horizon, or layer. The soil material may be sandy or clayey, and it may be cemented by iron oxide, silica, calcium carbonate, or other substance.

HYDROLOGIC CYCLE—A term denoting the circulation of water from the sea, through the atmosphere, to the land; and, thence, with many delays, back to the sea by overland and subterranean routes, and in part by way of the atmosphere without reaching the sea.

INCORPORATED AREAS—A legally organized group that works a single unit (City).

INDIAN LANDS

1. Reservation

   An area of Indian ownership designated by Treaty, Congressional Act or Executive Order.

2. Trust Lands

   Lands owned by Tribes and Indian individuals where fee ownership is held in Trust by the United States for the Indian Tribe.

3. Restricted Lands

   Lands owned by Indians, title held by the individual but disposition or alienation restricted by the United States.

INDUSTRIAL WATER—The industrial category includes those major water-using industries whose size is related to a significantly large population than that of the local area and whose water needs are not normally supplied through a municipal distribution system. For the purposes of this analysis, these industries are the following:

Pulp and paper
Other major forest products
Food processing
Petroleum processing
Primary metals
Thermal and nuclear power

INFILTRATION—The flow of a fluid into a substance through pores or small openings. It connotes flow into a substance in contradistinction to the word percolation, which connotes flow through a porous substance.

IRRIGATED LAND—Land receiving water by controlled artificial means for agricultural purposes from surface or subsurface sources.

IRRIGATED LAND, FULL SERVICE—Irrigated land with a full and adequate water supply.

IRRIGATED LAND, PARTIAL SERVICE—Irrigated land with a partial and inadequate water supply.

IRRIGATION REQUIREMENT, CROP—The amount of irrigation water in acre-feet per acre required by the crop; it is the difference between crop consumptive use requirement and effective precipitation.

LACUSTRINE DEPOSITS—Stratified materials deposited by lake waters.

LAND ADEQUATELY MANAGED OR TREATED—This group includes all land on which the use, management, and treatment meets the minimum standards of the conservation programs of the SCS, the Soil Conservation Districts, the Indian Service, or of the Federal Land Management Agency concerned. It includes all types of management, vegetation, and mechanical practices.

LAND AREA—The solid portion of the earth's surface including bodies of water less than 40 acres and streams of less than 1/8 mile wide.

LAND CAPABILITY CLASS—A group of capability subclasses and units that have the same relative degree of hazards or limitations. The risks of soil damage or limitation in use become progressively greater from Class I to Class VIII.

LAND CAPABILITY SUBCLASS—A group of capability units which have a major conservation problem, either, e, erosion and runoff; w, excess water; s, root zone limitations; or c, climatic limitations.

LAND CAPABILITY UNIT—A grouping of one or more individual soil mapping units having similar potentials and continuing limitations or hazards. The soils are sufficiently uniform to produce similar crops, require similar conservation treatment, and have comparable productivity.

LAND, POTENTIALLY IRRIGABLE—Land having soil, topography, drainage, and climatic conditions suitable for irrigation.

LAND REQUIREMENTS—The quantity and quality of land needed for residential, commercial, industrial, etc. development.

LAND RESOURCE—An area of land containing or supporting all or some of certain resources in some combination. The resources include soil, water, timber, forage, wildlife, and minerals.

LAND RESOURCE AREA—Broad, geographic area having similar soil, climatic, geologic, vegetative, and topographic features.

LAND RESOURCE REGION—Geographically associated major land resource areas which divide the United States into 20 physiographic regions uniform enough to be significant for national planning.

LAND TREATMENT MEASURES—The application of vegetative measures, tillage practices, and structural installations, individually or in selected combinations, according to land needs and use, to control runoff, prevent erosion, increase fertility and improve the soil.

LAND USE—Primary occupier of a tract of land grouped into classes with similar characteristics, i.e., urban, rural, cropland, rangeland, forest land, or other.

LAND USE PLAN—A proposal for the future pattern of land according to a classification system.

LANDSCAPE—(As used in soil geography) The sum total of the characteristics that distinguish a certain area on the earth's surface from other areas. These characteristics are the result not only of natural forces, but of human occupancy and use of the land. Included among them are such features as soil types, vegetation, rock formations, hills, valleys, streams, cultivated fields, roads, and buildings.

LEACHING REQUIREMENT—The amount of water required to move residual salts out of the root zone and maintain an adequate soil-salt balance for crop production.

LOCATION QUOTIENT—A number, generally in index form, which shows the relative importance of an industry in a region compared to the importance of all industries combined in the region.

LOESS—Soil material consisting primarily of uniform silt particles that were transported and deposited by wind.

MEAN LOWER LOW WATER—The level of the lower of two daily low tides averaged over a long-term period. It is the datum used for measuring the depth of navigation channels at all seaports on the West Coast of the United States and Canada.

METALS—Any of a class of chemical elements, as iron, gold, aluminum, etc., generally characterized by ductility, malleability, luster and conductivity of heat and electricity.

MICROCLIMATE—Local climatic conditions, brought about by the modification of general climatic conditions by local differences in elevation and exposure.

MINERALS, CONSTRUCTION—Naturally occurring mineral assemblages used primarily in the construction industry.

MINERAL FUELS—Naturally occurring carbonaceous minerals that include petroleum, coal, and natural gas.

MINERAL RESERVES—Discovered ore, coal, petroleum, or natural gas of established extent and grade producible but not yet produced.

MINERAL RESERVES,ECONOMIC—Profitable to mine under the technical and economic conditions existing at time of production.

MINERAL RESERVES,ECONOMICALLY RECOVERABLE—Extractable over a reasonable period of time at a cost which allows for a return on investment plus a reasonable profit.

MINERAL RESERVES, INDICATED—Tonnage and grade computed from measurements, samples, or production data, and from projection on geological evidence.

MINERAL RESERVES, INFERRED—Quantitative estimates based upon broad knowledge of the geology of the deposit for which there are few samples or actual measurements.

MINERAL RESERVES, MEASURED—Tonnage computed from dimensions revealed in outcrops, trenches, workings, and drill holes with grade derived from detailed sampling.

MINERAL RESOURCE—Known mineral deposit that is regarded as having present or future utility.

MUCK—Fairly well decomposed organic soil material, relatively high in mineral content, dark in color, and accumulated under conditions of somewhat poor drainage.

MUNICIPAL WATER—The municipal category includes not only urban domestic water use but also those other civic, commercial, and small industrial uses which are typically supplied through a municipal distribution system and the magnitude of which is related to local population.

NATIONAL FOREST LANDS—Federal lands which have been designated by Executive Order or Statute as national forests or purchase units, and other lands under the administration of the Forest Service, including experimental areas and Bankhead-Jones Title III lands.

NEUTRAL SOIL—A soil that is not significantly acid or alkaline; strictly one having a pH of 7.0; practically, one having a pH between 6.6 and 7.3.

NONMETALS—Naturally occurring mineral or assemblage of minerals that lack typical metallic properties such as cement minerals, sand and gravel, stone, lime, clay, phosphate, and potash.

NONSTOCKED AREA—An area of commercial forest land less than 10 percent stocked with growing-stock trees.

NONSTRUCTURAL MEASURES—Measures for managing, utilizing, or controlling water and related lands without structural development to achieve the desired objective. Such measures include flood plain zoning, flood warning systems, legal restraints, and preservation, as well as the more common land management measures.

OPEN SPACES—Land which is not occupied by a man-made structure.

ORTSTEIN—Hard, irregularly cemented, dark-yellow to nearly black sandy material formed by soil-forming processes in the lower part of the solum. Similar material not firmly cemented is known as orterde.

OTHER LAND—All land not classified as cropland, rangeland, or forest land is included in this group. Other land includes barren areas, urban areas and roads, as well as other miscellaneous occupancy.

OUTDOOR RECREATION AREA—A land and/or water area where outdoor recreation is recognized as the dominant or one of the major resource management purposes.

PEAT—Unconsolidated soil material consisting largely of undecomposed or slightly decomposed organic matter accumulated under conditions of excessive moisture.

PER CAPITA PERSONAL INCOME—Total personal civilian income divided by total civilian population. It may also be called per capita income.

PERCOLATION—The movement, under hydrostatic pressure, of water through the interstices of a rock or soil.

PERMEABILITY—The quality of a soil that enables water or air to move through it. The permeability classes are (1) very slow, less than 0.05 inch per hour; (2) slow, 0.05 to 0.20 inch per hour; (3) moderately slow, 0.20 to 0.80 inch per hour; (4) moderate, 0.80 to 2.50 inches per hour; (5) moderately rapid, 2.50 to 5.0 inches per hour; (6) rapid, 5.0 to 10.0 inches per hour; and (7) very rapid, more than 10.0 inches per hour.

PHYSIOGRAPHIC UNITS—Contrasting areas in the landscape that have general similarity in the range of environmental, topographic and physical soil characteristics.

PILE DIKE—A permeable groin of piling and quarry rock used to reduce flow in one portion of a stream to promote deeper water in the navigation channel.

PLAN FORMULATION—The process of selecting from a group of alternative potentials a plan of use and development.

PLANNING—A process of determining needs and influencing and shaping future public policy to serve those needs effectively.

PLANOSOL—A group of soils with cemented or compacted subsoil layers.

POINT ANALYSIS (ECONOMICS)—An analytical system which portrays an area's economy at a given point in time relative to some larger area (e.g., the nation) of which it is a part.

POLLUTION—Pollution is the alteration of the physical, chemical, or biological properties of water, or a discharge of any substance into water, which adversely affects any legitimate beneficial water use.

POTENTIALLY IRRIGABLE LAND—Land having soil, topography, drainage, and climatic conditions suitable for irrigation.

PRECIPITATION—As used in hydrology, precipitation is the discharge of water, in liquid or solid state, out of the atmosphere, generally upon a land or water surface. It is the common process by which atmospheric water becomes surface or subsurface water. The term "precipitation" is also commonly used to designate the quantity of water that is precipitated.

PRIMARY WASTE TREATMENT—The removal of settleable, suspended, and floatable solids from waste water by the application of mechanical and/or gravitational forces. In primary treatment, unit processes such as sedimentation, flotation, screening, centrifugal action, vacuum filtration, dissolved air flotation, and others designed to remove settleable, suspended, and floating solids have been used. Generally, a reduction in dissolved or colloidal solids has been obtained in primary treatment, but this effect is incidental and not the planned purpose of primary treatment.

PUBLIC DOMAIN LANDS—Original public domain lands which have never left Federal ownership; also includes lands in Federal ownership which were obtained by the Federal Government in exchange for public lands, or for timber on public lands.

PUGET SOUND AND ADJACENT WATERS STUDY AREA—The drainage Basins of all rivers, major and minor, between the Cascade and Olympic Mountains which flow into Puget Sound, Georgia Strait or the Strait of Juan de Fuca.

SUBAREA (THE BASINS)—The subdivisions of the Puget Sound and Adjacent Waters Study Region defined along drainage basin boundaries for study and report purposes. The Puget Sound and Adjacent Waters Study Areas and river basins are the:

1. Nooksack-Sumas
2. San Juan Islands
3. Skagit-Samish
4. Whidbey-Camano Islands
5. Stillaguamish
6. Snohomish
7. Cedar
8. Green
9. Puyallup
10. Nisqually
11. Deschutes
12. West Sound
13. Elwha-Dungeness

PUGET SOUND AND ADJACENT WATERS STUDY LAND AND WATER AREA LAND USE CATEGORIES:

Built-up (Intensive Uses)—Railroads, roadways, airports, rural residential (where more than three houses to ten acres), industrial areas, and cemeteries.

Cropland—All arable land (land which has been plowed and can be plowed without other preparation).

Forest—All land having a growth of timber species (more than 10 percent canopy cover regardless of age or size but excluding areas within the section which were classed as rural non-agricultural or urban due to density of housing).

Range—Unplowed open lands (less than 10 percent canopy cover); usually tidal or open prairie-like areas.

Rural Non-Agricultural—Farmsteads, rural residences (where three or less to ten acres), riverwash, mines.

Water—Salt water and fresh water.

RAINFALL—The quantity of water that falls as rain. Not synonymous with precipitation.

RANGE, IMPROVABLE—Range which is feasible to treat, that needs treatment in the sense of establishment or re-establishment of vegetation, improvement of cover, protection of vegetation, and management of water.

RANGE, IMPROVED—Range that has been treated and is maintained in such condition.

RANGE, NONIMPROVABLE—Range which is not subject to improvement because of present physical and/or economic limitations.

RANGELAND—Land in grass or other long-term forage growth of native species used primarily for grazing. It may contain shade trees or scattered timber trees with less than 10 percent canopy. It includes grassland, land in perennial forbs, sagebrush land, and brushland other than sage.

RANGELAND, IRRIGATED—Land in grass, or other long-term forage growth, of native species to which water is applied by controlled artificial measures.

RECHARGE (GROUND WATER)—The addition of water to the zone of saturation. Infiltration of precipitation and its movement to the water table is one form of natural recharge; injection of water into an aquifer through wells is one form of artificial recharge.

RECREATION AREA, DEVELOPED—Land that is developed with any type of recreation facilities, recreation roads or other visitor improvements. Also included is land adjacent to facilities that receive intensive human use. All or most land in recreation "sites" is considered to fall in this category.

RECREATION AREA, MULTIPLE-USE—Land which is, or can be developed and managed for recreation in combination with other uses.

RECREATION AREA, UNDEVELOPED—Land adjoining a developed recreation area that provides recreation activities such as hunting, hiking, and nature walks. Recreation will be the primary use of such land.

RECREATIONAL NAVIGATION—Primarily use of vessels for the owner's leisure time enjoyment, but also includes charter and for-hire vessels catering to the general public's recreation.

RECURRENCE INTERVAL—The average number of years within which a given event will be equaled or exceeded.

REGIONAL SHARE COEFFICIENT—Change in area employment in specified industry from base year to terminal year divided by the base year area employment in specified industry, less relative change in national employment in specified industry.

REGIONAL SHARE EFFECT—Shift in employment between two time periods which are attributed to above average or below average growth in the specified area industry (derived by multiplying base year employment in a specified area industry by the regional share coefficient).

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RESERVOIR—A pond, lake or basin, either natural or artificial, for the storage, regulation, and control of water.

RESIDENTIAL AREAS—Land utilized for dwelling units, (single-family, multi-family, high-density).

RESIDUAL OR SEDENTARY MATERIAL—Soil material presumably developed from the same kind of rock as that on which it lies.

RILL EROSION—Removal of soil by running water with formation of shallow channels that can be smoothed out completely by normal cultivation.

RUNOFF—That part of the precipitation that appears in surface streams. It is the same as streamflow unaffected by artificial diversions, storage or other works of man in or on the stream channels.

RURAL-DOMESTIC WATER—The rural domestic category includes water uses for domestic needs, stock watering, small scale irrigation, etc., or individual homes, farms or ranch . and rural centers with a population of less than about 250 people.

RURAL POPULATION—All population not classed as urban and is divided into rural farm and rural nonfarm population.

> **RURAL FARM POPULATION**—All residents living on farms of less than ten acres yielding production which sold at $250 or more in the previous year, or of ten acres or more with production sold at $50 or more in the previous year.
>
> **RURAL NONFARM POPULATION**—*All rural population* not classed as farm. This includes residents of unincorporated settlements, hamlets and villages and incorporated cities, boroughs, villages, and towns, both categories having less than 2,500 population.

SALINE SOIL—A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

SAND—Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consists of quartz, but they may be any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

SECONDARY WASTE TREATMENT—The removal of dissolved and colloidal materials that in their unaltered state, as found in waste water, are not amenable to separation through the application of primary treatment. Secondary treatment is generally accomplished through unit processes such as bioabsorption, biological oxidation, wet combustion, other chemical reactions, absorption on surface-active media, change of phase, or other processes that result in the removal of colloidal and dissolved solids from waste waters.

SEDIMENT—Fragmental or clastic mineral particles derived from soil, alluvial, and rock materials by process of erosion; and transported by water, wind, ice, and gravity. A special kind of sediment is generated by precipitation of solids from solution (i.e., calcium carbonate, iron oxides). Excluded from the definition is vegetation, wood, bacterial and algal slimes, extraneous light-weight artificially-made substances such as trash, plastics, flue ash, dyes, and semi-solids.

SERVICE AREA—An area described for planning purposes whose boundaries would include the future population or industrial activities which could logically and functionally obtain water supply and waste

disposal services from a central or integrated system or where the problems are so interrelated that the planning should be done on an integrated basis.

SHALLOW DRAFT–Commercial vessels with drafts less than 18 feet.

SHEET EROSION–The removal of a fairly uniform layer of soil or materials from the land surface by the action of rainfall and runoff water.

SHIFT ANALYSIS–An analytical technique to measure and classify regional economic growth over time. It defines regional growth in terms of its component parts; namely, growth in the region due to overall growth of the national economy, growth due to the industry-mix of an area, and growth due to geographic advantages or differences. This latter component is referred to as the area share component. Growth most often is defined in terms of either employment or income.

SILT–Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeters) to the lower limit of very fine sand (0.05 millimeters). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

SLICK SPOTS–Small areas in a field that are slick when wet because they contain excess exchangeable sodium, or alkali.

SLOPE–The incline of the land surface, usually expressed in percentage of slope, which equals the number of feet of fall per 100 feet or horizontal distance. In this report, slope is expressed as follows:

0 to 3 percent	Nearly level
3 to 7 percent	Gently sloping
7 to 12 percent	Moderately sloping
12 to 25 percent	Strongly sloping
25 to 40 percent	Steeply sloping
40 to 70 percent	Very steeply sloping
70 to 100 percent and steeper	Extremely steeply sloping

SMALL BOAT NAVIGATION–Use of self-propelled recreational and commercial fishing vessels, generally not more than 50 feet in length in the Columbia-North Pacific Region.

SOIL–A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

SOIL ASSOCIATION–A group of soils, with or without common characteristics, geographically associated in an individual pattern.

SOIL COMPLEX–A mapping unit consisting of different kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.

SOIL DEPTH–The depth of soil material that plant roots can penetrate readily to obtain water and nutrients. It is the depth to a layer that, in physical or chemical properties, differs from the overlying material to such an extent as to prevent or seriously retard the growth of roots or penetration of water. The depth classes are: (1) very deep, more than 60 inches; (2) deep, 40 to 60 inches; (3) moderately deep, 20 to 40 inches; (4) shallow, 10 to 20 inches; and (5) very shallow, 0 to 10 inches.

SOIL MAPPING UNIT–A portion of the landscape that has similar characteristics and qualities, and whose limits are fixed by precise definitions.

SOIL MORPHOLOGY–The physical constitution of the soil, including the texture, structure, porosity, consistence, and color of the various soil horizons, their thickness, and their arrangement in the soil profile.

SOIL PROFILE–A vertical section of the soil through all its horizons extending to 60 inches or a restricting layer.

SOIL RESOURCE GROUP–A grouping of land capability units, or soils that have similar cropping patterns, yield characteristics, responses to fertilizers, management, and land treatment measures.

SOIL SERIES–A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar.

SOIL STRUCTURE–The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles.

SOIL TEXTURE–The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are shown as follows:

General terms		Basic soil textural class names
Sandy soils–	Coarse-textured	(Sands
	soils	(Loamy sands
	(Moderately coarse	(Sandy loam
	(	
	(	
Loamy soils–	(Medium textured	(Very fine sandy loam
	(soils	(Loam
	(	(Silt loam
	(	(Silt
	(	
	(Moderately fine-	(Clay loam
	(textured	(Sandy clay loam
	(soils	(Silty clay loam
Clayey soils–	Fine textured	(Sandy clay
	soils	(Silty clay
		(Clay

SPECIFIC CAPACITY–The yield of a well per unit of drawdown after a specified period of pumping. Generally expressed as gallong per minute (gpm) per foot of drawdown.

STAGE OF ECONOMIC GROWTH–A period in the life cycle of an economic unit (business organization; urban place; region) distinguished by (1) input mix or output mix, and (2) interunit trading patterns.

STAND, MEDIUM-STOCKED–A stand that is 40 to 69 percent stocked with present or potential growing-stock trees.

STAND, POLETIMBER–Stand at least 10 percent stocked with growing-stock trees, with half or more of this stocking in sawtimber and poletimber trees, and with poletimber stocking exceeding sawtimber stocking.

STAND, POORLY STOCKED–Stand that is 10 to 39 percent stocked with present or potential growing-stock trees.

STAND, SAPLING AND SEEDLING–Stand at least 10 percent stocked with growing-stock trees, with more than half of this stocking in sapling and/or seedlings.

STAND, SAWTIMBER–Stand at least 10 percent stocked with growing-stock trees, with half or more of this stocking in sawtimber and poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

STAND, WELL-STOCKED–A stand that is 70 percent or more stocked with present or potential growing-stock trees.

STANDARD METROPOLITAN STATISTICAL AREA (SMSA)–A county or group of counties containing at least one city of 50,000 inhabitants or contiguous cities with a combined population of 50,000 or more. In addition to the county containing such city or cities contiguous counties are included in an SMSA if they are metropolitan in character and are integrated socially and economically with the central city. The criteria of metropolitan character relate to the attributes of the outlying county as a place of work of residence for a concentration of nonagricultural workers and stipulate that at least 75 percent of the labor force in a county must be nonagricultural and, usually, that the county must have 50 percent or more of its population living in contiguous minor civil divisions, with a density of at least 150 persons per square mile.

STATIC LEVEL (GROUND WATER)–The level of water in a nonpumping or nonflowing well. For the purpose of computing the drawdown, it generally is the water level immediately before pumping begins.

STOCK, GROWING–Live trees of commercial species that are now or may be expected to become suitable for use as industrial wood. There are three major categories: (1) Sawtimber trees (11.0" + d.b.h.); (2) Poletimber trees (5.0" to 10.9" d.b.h.); and (3) Sapling and Seedling trees (less than 5.0" d.b.h.).

STOCK, GROWING (VOLUME)–Net volume in cubic feet of live sawtimber trees and live poletimber trees from stump to a minimum 4.0 inch top (of central stem) outside bark. Net volume equals gross volume less deduction for rot and missing bole sections.

STOCK, NONGROWING–Trees which do not meet the requirements for growing stock. There are three broad groups recognized; (1) Cull trees; (2) Mortality trees; and (3) Salvable dead trees.

STOCKING–The extent to which growing space is effectively utilized by present or potential growing–stock trees of commercial species. "Degree of stocking" is synonymous with "percentage of growing space occupied" and means the ratio of actual stocking to full stocking for comparable sites and stands.

STORAGE–Water naturally or artificially impounded in surface or underground reservoirs.

STORAGE CAPACITY, ACTIVE (USABLE)–The volume normally available for release from a reservoir below the stage of the maximum controllable level. (Total capacity less inactive and dead capacity.)

STORAGE CAPACITY, CONSERVATION–Storage capacity available for all useful purposes such as municipal water supply, power, irrigation, recreation, fish and wildlife, etc., excluding joint use and exclusive flood control capacity.

STORAGE CAPACITY, DEAD–The volume of a reservoir below the sill or invert of the lowest outlet.

STORAGE CAPACITY, EXCLUSIVE FLOOD CONTROL–The space in reservoirs reserved for the sole purpose of regulating flood inflows to abate flood damage.

STORAGE CAPACITY, INACTIVE–The portion of live storage capacity from which water normally will not be withdrawn, in compliance with operating agreements or restrictions.

STORAGE CAPACITY, JOINT USE–The volume of a reservoir available to store water jointly for flood control and conservation purposes.

STORAGE CAPACITY, LIVE–The volume of a reservoir exclusive of dead and surcharge storage capacity.

STORAGE CAPACITY, SEDIMENT–The volume of reservoir planned for the deposition of sediment.

STORAGE CAPACITY, SURCHARGE–The volume of a reservoir between the maximum water surface elevation for which the dam is designed and the crest of an uncontrolled spillway, or the normal full-pool elevation with the crest gates in the normal closed position.

STORAGE CAPACITY, TOTAL–The total volume of reservoir exclusive of surcharge.

STREAM–A general term for a body of flowing water. In hydrology, the term is generally applied to the water flowing in a natural channel as distinct from a canal. More generally, as in the term stream gaging, it is applied to the water flowing in any channel, natural or artificial.

STREAM, EFFLUENT–A stream or reach of stream fed by ground water. It is also called a gaining stream.

STREAM, EPHEMERAL–A stream that flows only in response to precipitation.

STREAM, INFLUENT–A stream that contributes water to the zone of saturation.

STREAM, INTERMITTENT–A stream that flows only part of the time or through only part of its reach.

STREAM, PERENNIAL–A stream that flows continuously.

STREAMFLOW–The discharge that occurs in a natural channel. Although the term discharge can be applied to the flow of a canal, the word streamflow uniquely describes the discharge in a surface stream course. Streamflow is a more general term than runoff, as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

STREAMFLOW REGULATION–The artificial manipulation of the flow of a stream.

SUBIRRIGATED LAND–Land with a high water table condition, either natural or artificially controlled, that normally supplies a crop irrigation requirement.

SUBSOIL–Roughly, that part of the soil profile below plow depth. Generally 10" to 32" below surface.

SUBSTRATUM–Any layer beneath the soil profile. It applies to the parent material and to layers unlike the parent material that lie below the subsoil.

SUBURBAN AREAS–The outlying districts of a city, variously connoting a combination rural and urban features.

SUMMER SALT-WATER DRAFT–The term generally used to represent the draft of fully loaded vessels.

SURFACE SOIL–The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 10 inches in thickness. The plowed layer.

TALUS–Fragments of rock and soil material collected at the foot of cliffs or steep slopes, chiefly as a result of gravitational forces.

TERRACE (GEOLOGICAL)–An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

TERTIARY OR ADVANCED WASTE TREATMENT–Selective application of biological, physical, and chemical separation processes to effect removal of organic and inorganic substances that resist conventional treatment practices.

TRANSPORTATION, URBAN AND BUILT-UP AREA (TUB)–Includes cities, villages, other built-up areas of more than 10 acres, industrial sites, railroad yards, cemeteries, airports, golf courses, shooting ranges, institutional and public administrative sites; and the area devoted to roads and railroads.

TYPES–A classification of forest land based upon the predominant species in the present tree cover. Types are determined on the basis of majority of stocking by all live trees of various species, considering both sizes and spacing.

ULTRA BASIC ROCK–Very rich in calcium and magnesium.

UNINCORPORATED AREAS–A town in which is not legally organized to function as a single unit.

UPLAND (GEOLOGY)–The land consisting of material unworked by water in recent geologic time and generally at a higher elevation than the alluvial plain or stream terrace; land above the lowlands along rivers or between hills.

URBAN POPULATION–All persons living in (a) places of 2,500 inhabitants or more incorporated as cities, boroughs, villages, and towns (except towns in New England, New York, and Wisconsin); and (b) the densely settled urban fringe, whether incorporated or unincorporated, or urbanized areas.

URBANIZED AREA–Delineated in advance of enumeration, by establishing boundaries for urban fringe areas, usually with population density of 1,000 or more per square mile, and unincorporated places of 2,500 or more population so as to provide a meaningful separation of urban and rural population particularly in the vicinity of the larger cities. An urbanized area contains at least one city of 50,000 inhabitants or more, as well as the closely settled surrounding area.

VOLUME ALL-TIMBER–Net volume in cubic feet of live and salvable dead sawtimber trees and poletimber trees of commercial species, and cull trees of all species from stump to a minimum 4.0-inch top outside bark.

VOLUME, LIVE SAWTIMBER–Net volume in board feet of live sawtimber trees of commercial species. Net volume equals gross volume less deduction for rot, sweep, crook, and other defects that affect use for lumber.

WATER AREA—Water areas of more than 40 acres and water courses more than 1/8 mile wide.

WATERSHED—A term to signify drainage basin or catchment area.

WATERSHED PROTECTION—The treatment of watershed lands in accordance with such predetermined objectives as the control of erosion, stream flow, silting floods, and water, forage, or timber yield.

WATER TABLE—The upper surface of a zone of saturation. No water table exists where that surface is formed by an impermeable body.

WATER YIELD—Runoff, including ground water outflow that appears in the stream, plus ground water outflow that leaves the basin underground. Water yield is the precipitation minus the evapotranspiration.

WILDERNESS AREAS—A collective term used to describe all major areas specially classified and set aside for their primitive and relatively undisturbed esthetic values.

ZONING—A legal and administrative devise for controlling and insuring a reasonable use of land, usually associated with police power.